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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVII MAY, 1937 WHOLE NO. 322

MATHEMATICS FUNCTIONING IN INDUSTRY*

BY RAYMOND F. FORBES

Head of the Research Department, Indianapolis Power and Light Company, Indianapolis, Indiana

I have been assigned this subject, "The Function of Mathematics in Industry." No one but a mathematics teacher could conjure up such an appropriate word as "function" to use in this topic, "The Function of Mathematics in Industry."

In searching in my own mind for what I thought you teachers want in such an address, I came to this conclusion: that you are asking me, "Is there really a need for pure mathematics and for mathematical training in the world of industry?" My answer is emphatically "yes."

By way of introduction, and inasmuch as you of my audience are all teachers, let us contrast very briefly early education in medieval Europe with our present educational methods. I have been much interested in reading a new book *Trial Blazers of Science* by Martin Gunipert, which develops very clearly this thought: that education in Europe even as late as the sixteenth and seventeenth centuries was a peculiar school on logic to train and subtilize the intellect, but to train men to think only abstractly. Intellectual progress was not to be measured in results in original, new thought, which was under an edict or at least in strict confinement. Only when men began to pioneer in original thought differing from accepted theories and dogmas taught in the schools were real discoveries and intellectual progress made. Today, still, it is uncautious, non-

* An address delivered before The Indianapolis Mathematics Club, February 16, 1937.

orthodox thought that makes possible the greatest advance in our life.

Gradually, with time and the growth of the industrial age came the development of our technical and vocational education systems. Business and industry having become highly specialized, educational methods have sought to follow this change, to meet the need of the times, and to equip men for the new industrial system. We seek today to teach a man to think on subjects he can apply. Possibly the pendulum has swung too far from the abstract teaching to the teaching of the practical, the utilitarian, but this fact remains, men in industry still need training in abstract subjects, even in abstract mathematics. Even as the medieval schools forbade one's mind to indulge in flights of the imagination, just so the mind that is directed only toward the practical and the concrete does not indulge in such flights of the imagination nor enlarge its scope.

The real quality wanted and needed in industry in the pupils you teachers send us is not knowledge alone, but resourcefulness. What I mean is that the art which creates things great or small is not the capacity for solving problems alone. It is comparatively easy to solve a problem when the problem is stated, but the student who can recognize and visualize a problem, and orient the solution in the direction that will lead to its conclusion is the man who will succeed not only in mathematics, but in industry. The first function of training in mathematics, then, is to develop resourcefulness in thought.

Let me here interpose a criticism of some of my mathematics teachers as I remember them. If a student orients the solution of a problem correctly but fails to arrive at the correct absolute answer because of some careless mistake in manipulation, should he be graded zero? Accuracy throughout the entire process of solution is essential and necessary, but the most important element of such training in later life in the industrial world to the pupil solving a mathematics problem is that he understand how to orient the solution.

Another quality needed in men in industry that is developed by training in mathematics, and I think this is the supreme quality, is that they be able to analyze and think clearly. The man who sees only with blurred vision, the man to whom distinctions are difficult, the man who cannot separate beginnings from endings, or see the difference between a hypothesis and a fact—what can industry do with such a man of foggy mind?

A capacity to analyze enables one to perceive the strong and the weak points in a proposition, to discover the limitations of some men and the latent possibilities in others, to locate the defects in a business organization and to see how to convert those weaknesses into strength. How then does mathematical training teach us to analyze and think clearly?

To think clearly, psychologists tell us requires that our minds function in five logically distinct steps: (I) a felt difficulty; (II) its location and definition; (III) suggestion of possible solution; (IV) development by reasoning of the bearings of the suggestion; (V) further observation and experiment leading either to its acceptance or rejection; that is the conclusion of belief or disbelief. Does the solution of mathematical problems measured by these five steps train us to think clearly? In the mathematics class: (I) the felt difficulty is the statement in so many words of the problem; (II) its location and definition is the conversion of the problem stated into a mathematical equation or system of equations; (III) the suggestion of a possible solution is the recognition of the process which will affect the solution; (IV) development by reasoning of the bearings of the solution is the mathematical expansion of the method of the solution to its ultimate completion; (V) the further observation and experiment leading to its acceptance or rejection is the proof or disproof of the correctness of the solution by substitution in the original equations. Thus does mathematics teach men the art of analysis and clear thinking.

Yet another essential quality of a successful man in the industrial world is that he must have a broad horizon. Industry wants men with a broad horizon. Not so very long ago our Company made a survey by questionnaire of every one of the employees, seeking to learn of every man his outside interests, his religious and fraternal affiliations, his qualifications by education and experience for work other than his present occupation, his interests, if any, in sports, music, dramatics, public speaking, civic affairs, and even his hobbies. Now I am not vain enough to believe our Company is the only industry seeking such information. Why does industry want men of wide horizon? A man who cannot see beyond his own dooryard, his own city, his own business, may make an excellent clerk, but he certainly will make a poor executive. The man who has mastered bookkeeping, but cannot see the broad panorama of the entire business, who cannot sense what millions around him are thinking,

who is blind to fiction, drama, art, aviation, new problems and developments in the advance of science on all fronts—well, such a man will keep an excellent set of books forever and be out of the way of men of determined ambition and creative energy who know what they want in the world.

Mathematics broadens a man's horizon through a most important principle of education which you teachers call the law of apperception. An object or subject not interesting in itself may become interesting through being associated with an object in which an interest already exists. The two associated objects then grow together, the interesting portion shedding its interest over the whole. Thus, things not interesting in their own right borrow an interest which becomes as real and as strong as that of any natively interesting thing. Laplace, a French astronomer and mathematician, said "what we know is nothing; what we have yet to learn is immense." You and I read with great interest of the successful casting of the glass that is to form the 200 inch reflecting telescope of Mt. Wilson observatory. When the immense telescopic disc after two years of precise grinding and polishing to a mathematically absolute paraboloidal shape is turned to the heavens, man's new reach into space will bring into view, it is estimated, one hundred million more star systems than we now know. Only a mathematically trained mind can comprehend or appreciate the significance of such an event to the advancement of our knowledge of interstellar space, of worlds as yet unknown to us, and of energies travelling through distances measurable only in millions of light years to reach our earth from their source. Thus mathematics through apperception functions in industry in giving men a wide horizon of interests.

This wider horizon, this greater interest in life was what Poincaré, another French mathematician, had in mind when he defined mathematics as "The art of giving the same name to different things." Thus the person with a background of mathematics has learned to put into the same class such unlike objects as a star, an orange, a rain drop, and a bubble because he calls them all by the common name of sphere; he groups in a class such diverse things as a sunbeam, a coiled spring, a waterfall, and a piece of coal because he understands they all contain a "common factor" which we call energy.

There is an old story of a farmer, who, advertising his farm for sale, called special attention to its splendid central location.

"You can start from my farm," he said, "and go any place in the world." A thorough training in mathematics is like that farmer's farm—from it we can go any place in the world, through countless paths to undreamed of fields of interest and pleasure, through other paths that will be short-cuts to profit and success in our domestic, social, and industrial life. It is, I think, axiomatic that a man successful in the world of industry is a man of wide horizon, and the corollary is also true that the man of wide horizon will be successful in industry. Richness and variety of interests give perspective and meaning to events and trends in social and scientific progress that men of provincial environments let pass unnoticed. Mathematics places a ferment in an ordinary mind that makes it seethe with critical speculations and adds breadth and acuity to mental vision. Keen observation, intelligent analysis, retentive memory, inquiring imagination, restless curiosity about things and happenings are the rewards of a mastery of mathematics.

Thus, friends, have I endeavored to show you that abstract mathematics has an important function in industry in developing in men those qualities of character industry needs: resourcefulness, power of analysis and clear thinking, and a wide horizon. Industry even in this industrial age, is still built of men, valued for their philosophical and cultural worth.

I should like now to speak briefly on the practical applications of mathematics in industry.

I have studied mathematics through trigonometry, algebra, plane and solid geometry, analytical geometry, integral and differential calculus, and differential equations. I have never taken a prescribed course in college algebra, but I have had to learn the use of determinants and Horner's method for determining irrational roots.

Perhaps I can best show you teachers what mathematics is most needed in industry by some of my own observations of the types of calculations least understood by graduates of our high schools and colleges as well. We are of course dealing now with men in industrial pursuits where application must be made of pure mathematics.

At the top of the list, perhaps, of things the average high school graduate does not thoroughly understand how to use is logarithms. Of course, we have calculating machines on which we can multiply, divide and even extract square roots, but such machines are not always at hand, and many of our problems in

industry involve the use of fractional and negative exponents, problems solvable by the use of logarithmic tables. A thorough understanding of the use of logarithms is very helpful in industry.

Another type of mathematic problem not understood by mathematics graduates is the use of the series, particularly the geometric series. The social security law has awakened interest among men in industry in the geometric series. Not many men can build up a geometric series and evaluate it. Problems of retirement, of mortgages, creation of sinking funds and amortization accounts involve the use of the series. Teach your pupils to thoroughly understand the series.

Still another most important branch of mathematics in industry is the use of graphs. So much more information can be visualized at a glance from a graph than from a table of figures or statistics, that graphs have a real function in industry. Here again, a knowledge of the meaning of logarithms is useful, for a logarithmic graph often is useful in showing how business trends follow a mathematical law where a uniform scale graph would not show such relationship. Knowledge of how to plot a curve from empirical data and how to determine the equation of the curve for the purpose of extending it beyond the range of the empirical data is useful information. Graphs are much used in industry.

I have already spoken of the value of mathematical training as a means for orienting our minds in the solution of any kind of problem. I would recommend to you teachers of algebra that you give your pupils much training in building up and solving simultaneous equations, problems in which the pupil must first use his mind in building the equations before the solution can be begun.

If only students while in school could realize the value and importance of the things we study, both for their practical value and their cultural value. Mathematical problems in industry are infinite—because of the increasing value of land, what shape building can I design on my ground to afford maximum floor space? Competition can only be met by decreased material cost; how can my product be designed of maximum strength and durability with minimum weight? What additions to plant must be made and what volume of business will we do next year, or even ten years hence? These are only a few questions asked in industry when it turns to mathematics for its

answers. Yes, industry needs men trained in mathematics, because of both the cultural and the practical value of mathematical training. Give us the best mathematically trained students you can, for industry needs them.

SPRING RALLY OF SCIENCE AND MATHEMATICS TEACHERS

Science and Mathematics Teachers of Northeastern Ohio met at Western Reserve Academy, Hudson, Ohio, for their Spring Rally on Saturday, March 13, 1937.

The forbidding weather of the sessions of the two preceding years gave away to a beautiful March day with just enough frosty tang in the air and just enough snow flakes to warn that spring was just around the corner but not quite here. The Campus of old Western Reserve College now occupied by the modernized buildings of Western Reserve Academy gave an air of antiquity which was fitting to an occasion when teachers were meeting to have a good time while they discussed some of the very serious problems confronting present day teaching.

The setting for the meeting was perfect. The sessions were held in Community Meeting Place in Cutler Hall which is in the south end of the building where the north end is occupied by the beautiful Dining Hall of the Academy. This room is furnished with the antique furniture from the residence of Mr. James W. Ellsworth, whose success as a coal operator made it possible for him to become the benefactor of Hudson as well as the restorer of the Academy. The Radio Record Player was of the most modern type and in the hands of Academy students supplied wonderful musical entertainment of the highest cultural value.

The central thought of the Program, developed by the President Mr. A. Brown Miller, Mathematics of Fairmount Junior High School, Cleveland and Mr. Franklin R. Bemisderfer, Vice-president, General Science Teacher of East Technical High School was "What of the Future?"

The Program, separately given, speaks for itself.

Rarely have a hundred teachers sat through a program of such absorbing interest, so perfectly appropriate, without a single slow or stupid minute, with speakers who talked directly to their subjects without deviation and with thorough authority. It is impossible to reproduce for you the inspiration of the occasion. An equally great program is in contemplation for 1938 and it is hoped that you can be present.

The Glee Club of The Academy entertained with singing just before luncheon. At luncheon each table was presided over by two of the Academy boys. There is hope for America as long as we see boys of this sort coming up to take their places in seeing us through.

After Dr. Visscher's pictures and stories of Hawaii the afternoon was spend in "Doc" Simon's Sugar Bush. "Doc" is the new Vice-president of the Central Association of Science and Mathematics Teachers.

In 1938, the meeting will be held early in April that we may have a better opportunity to study wild-flowers and see the woods.

For the benefit of those who do not know, this Spring Rally is a revival of the similar meetings of teachers in Northeastern Ohio held years ago under the leadership of a like active body of teachers (before there was a WPA). The revival is five years old and going stronger than ever.

FRANKLIN T. JONES

VISUALIZING FLOWLINES IN FLUIDS

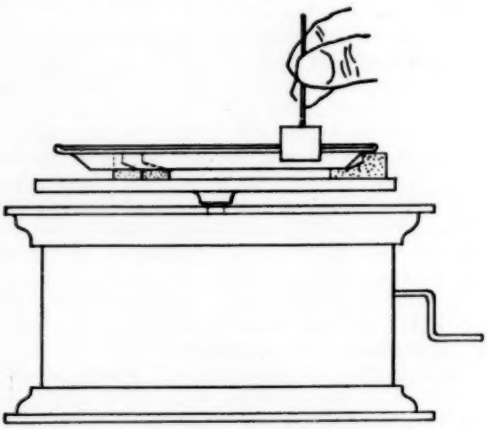
By John B. Leake

Crane Technical High School, Chicago, Illinois

"A picture," say the Chinese, "is worth ten thousand words." "A model I can work," says the American boy, "has a picture backed off the blackboard."

Books and illustrated lectures can be used to explain the flow of fluids past differently shaped objects, but more learning results if the student creates visible flowlines in a fluid, and makes his own drawings.

For the latter method, the writer uses an old phonograph, a pie pan full of water, and test objects of various shapes. The device is used as shown in the illustration, and the student follows the procedure outlined below.



Testing object in rotating fluid.

1. Wind the motor, fill pan nearly full of water, and put a pinch or two of lycopodium powder on the water. Excess powder should be blown off. Do not inhale this powder.
2. Throw starting lever, and hold square test object in the water. On your data sheet, sketch cross section of the object, and the visible flowlines around it, as made by the moving powder.
3. Repeat, using other objects, such as a cylinder, streamlined strut, two small cylinders held one behind the other, and any other shapes available.
4. Number each figure, so that it can be referred to in the writeup of the experiment, which should be in the usual form—Object, Apparatus, Method, Data, and Conclusion.
5. Place airfoil test object in the water so as to get least turbulence. Record flowlines visible.

6. Increase the angle of attack between the lower camber of the airfoil and the moving water. Observe bubbles starting around the trailing edge, and extending forward on the upper camber as angle of attack is increased. The above condition illustrates the airflow during stall of an airplane wing.

For precise observation, these objects can be attached to a protractor and indicator arm support, and it is evident that straight flow of water is superior to circular flow outlined above. However, for average class work, the objects can be held by hand, and the rotating water gives qualitative evidence.

Lycopodium powder coats the pan after it becomes soaked, and it is necessary to renew the surface coating on the water. If a few drops of oil are added to the water, the powder stays in suspension, and it is not necessary to add powder as frequently.

Experience indicates that boys delight in speeding up the rotation of the pan, in order to empty the water by centrifugal action. This is best avoided by screwing a cover over the governor adjusting screw.

On account of the knowledge of flowlines and streamlining gained from this experiment, and the negligible cost of the device we have found this experiment well worth while.

MAN MAY YET TAP ATOM'S ENERGY SAYS YALE SCIENTIST

Man may yet tap the atom for an almost unlimited store of energy, Dr. Ernest C. Pollard, Yale physicist, predicted in the Yale Scientific Magazine.

"Probably not, but yet—maybe" is the way he answers the query as to whether there will be practical release of energy from the atom. The key to such cheap energy would be the conversion of matter into energy, which is theoretically plausible. If atomic energy were achieved, the dreams of the ancient alchemists who hoped merely to turn lead into gold would fade into insignificance.

"The conversion of mass into energy involves multiplying by the square of the velocity of light," Dr. Pollard explained. "This gives us such hugh figures that the question arises: Can we make the energy available? It seems as though the fact that the atom's nucleus is so small must mean a huge waste of particles in transmuting it so that the energy is bought at a high cost, and yet the past five years have seen transmutations brought about on a millionfold greater scale. If we could multiply yet again by a hundred million then we might be successful."

Radioactive analysis may some day supplant ordinary chemical analysis, Dr. Pollard also predicted. Many elements have been produced in radioactive form and if every element can be made radioactive, the progress of chemical reactions will be traceable with a degree of refinement hitherto unattainable.

Because radiations, like X-rays, affect living things, changing the heredity of plants and animals, Dr. Pollard foresees that high energy radiations may enable man to anticipate evolution.

AN EASILY CONSTRUCTED STAR MAP

By William A. Porter

Independent School District No. 40, Chisholm, Minnesota

Few environmental factors generate more interest and are more easily presented to the elementary school child than the constellations and the more prominent fixed stars. We have found the star map a most useful device for building up interest in the environment, developing observation, and teaching the location and arrangement of the heavenly bodies.

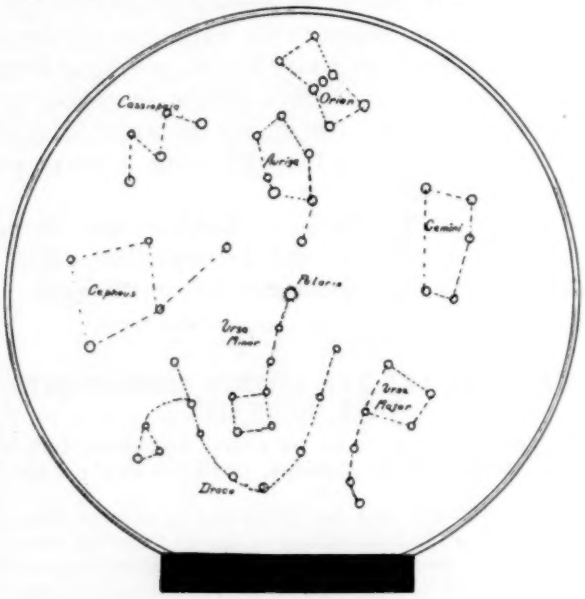


Fig. 1

The star map described here was constructed by the writer in cooperation with Miss Ida Orren, third grade teacher in the Roosevelt School, Chisholm, Minn. The materials are readily obtainable from any radio service man or wholesale radio company. They are as follows: a sheet of Masonite Presdwood 4 ft. square, 54 pilot light sockets and an equal number of 6 v. bulbs, a 6 v. transformer capable of delivering 5–7 amperes, and 8 switches.

A circle 4 ft. in diameter is drawn on the Presdwood sheet and cut with a scroll or band saw. On this sheet the teacher and the pupils plotted the constellations which they had previously selected and drawn on the blackboard. A $\frac{1}{2}$ in. hole is drilled

where each star should be and a rubber grommet inserted. The socket is then thrust through the hole in the grommet and is held securely. Christmas tree lights were first considered but were not used because they are rather large and require a series of eight lights. The pilot light bulbs give practically a point source of light, any number may be connected on a circuit, any six volt battery or transformer will illuminate them and the low

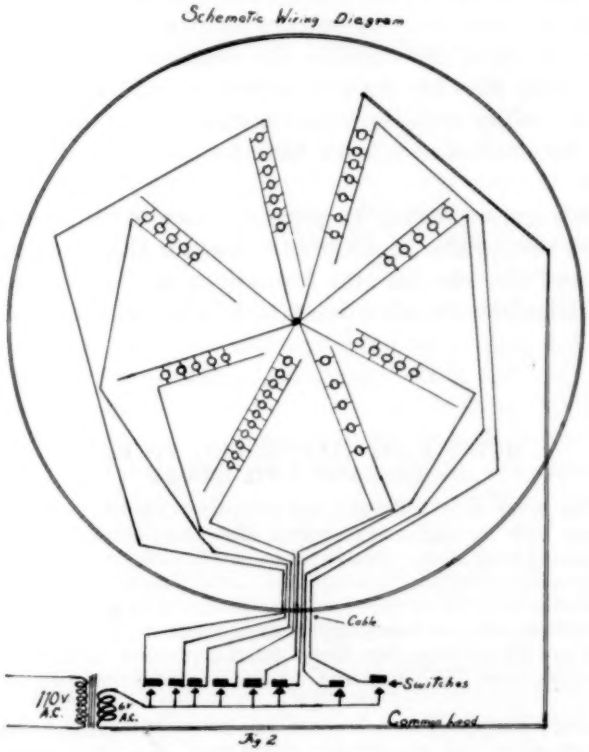


FIG. 2

voltage prevents possibility of shock or injury. Fig. 1 shows the arrangement of the constellations on the board. Fig. 2 shows the method of connecting the various circuits.

For this particular board each constellation was wired separately and one wire from each is brought together to form a common lead. The other wire from each constellation leads to a switch thus making it possible to control each star group separately. The switches and the step down transformer are mounted in a small box which is connected to the star map

by a seven foot cable containing the nine control wires. This arrangement allows the constellations to be controlled at some distance from the chart. One feature of the chart is its ability to show the positions of the constellations in the various seasons of the year by simply rotating the chart. The map is held upright by a simple easel. The number of constellations that may be turned on at one time depends on the capacity of the transformer and the size of the common or return lead wire. On a six volt circuit even a small voltage drop will materially change the brightness of the stars, so the common lead should not be smaller than size 14. All connections should be soldered with resin core solder to prevent poor contacts. The face of the chart should be enamelled a dark blue to furnish a suitable background.

An interesting assembly program may be built around the chart by having the pupils tell the legends that have been built up around the various star formations and at the same time illuminating the constellation which is being discussed.

SUN'S RAYS HARNESSED TO FIGHT DISEASE AND DECAY

The day when man will fight and conquer micro-organisms of disease and decay with the sun's rays or their laboratory-made equivalent seems to be drawing near. Steps already taken in this direction were described by A. R. Dennington of the Westinghouse Lamp Company at the meeting of the Canadian Section of the American Institute of Electrical Engineers.

Sunlight can kill micro-organisms even when its ultraviolet and infrared rays are filtered out, Mr. Dennington explained. The rays of shorter wavelengths, from 2537 Angstroms down, are the most effective at germ-killing.

Such rays harnessed in a lamp which has an extremely thin indrawn window or glass bulb are already being used, Mr. Dennington said, by physicians to destroy the germs of skin infections. At the opposite extreme of medical use are the eight sterilizing lamps installed over the operating table at Duke University Hospital to sterilize air during surgical operations and thus prevent wound infections.

For keeping meat safe by preventing mold growth during the tenderizing storage period, and for keeping mold out of bakery products, there is the tubular lamp made of special glass and resembling the blue neon sign tube.

Other lamps that give off sterilizing rays are being investigated in the hope of developing a ray method of sterilizing milk.

The ultimate hope of scientists working in this field of ray sterilization is to find ways and means of purifying the air to offset the danger of breathing in germs that are constantly being breathed out into the air. —*Science Service.*

THE SCIENTIFIC METHOD

Attitudes and Skills Essential to the Scientific Method, and Their Treatment in General Science and Elementary Biology Textbooks*

By Victor L. Crowell, Jr.
State Teachers College, Trenton, New Jersey

Statement of the Problem

It is generally agreed that science consists not only of facts which have been verified and classified, but that it is also a method of thinking. It is the belief of the writer that science teachers have concerned themselves unduly with the teaching of facts, to the neglect of science as a method by which the pupil can solve his own problems. Most persons will probably agree that facts have a place in any scheme of education if those facts serve as vehicles for the development of individually and socially worth while attitudes, appreciations, habits and skills, and are not considered solely as ends in themselves. The writer believes that many of the facts which are at present taught as isolated bits of knowledge might well be taught for the purpose of developing attitudes and skills associated with the scientific method of thinking. We know little at present as to which attitudes and skills are essential to the scientific method of thinking. Neither do we know very much concerning the best methods for teaching these attitudes and skills. It is the conviction of the writer that the topic of scientific method will not be adequately treated in the classroom until the authors of science textbooks recognize the importance of the subject and build the organization of their books around it. This is true because science textbooks probably determine to a large degree what topics shall be taught and the method by which they are taught. The writer also believes that before an individual can employ the scientific method he must first possess certain specific attitudes and skills which are fundamental to it. After the individual has acquired these attitudes, to the extent that his responses to certain stimuli are assured, and after he has acquired the skill necessary to execute his responses, he may then, if he uses them in a problematical situation for which

* This article is a summary of an unpublished dissertation presented to the Faculty of Rutgers University in May 1936 in partial fulfillment of the requirements for the degree of Doctor of Education.

he is consciously seeking the best solution, be said to employ the scientific method.

In view of the position just stated, it was the purpose of this study to:

(1) Ascertain some of the most important attitudes and skills involved in the scientific method.

(2) Find out in what manner, and to what extent, these attitudes and skills are treated in textbooks of general science and elementary biology used in the schools of New Jersey.

Procedure

A large portion of the available literature was examined to find out what the authors of books and magazine articles on philosophy, logic, science education, and science measurement, considered to be important elements of the scientific method. These elements were utilized to prepare a list of specific attitudes and skills involved in the scientific method. There were twenty-nine attitudes and twenty-five skills in this initial list.

For the purpose of this study an attitude was defined as, "a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related."[1] The term skill was used in its commonly accepted meaning which is given in the dictionary as, "knowledge of, and expertness in, execution or performance."[2]

Sixty-four individuals, representing forty-nine institutions in twenty states in different sections of the United States evaluated the list of attitudes and skills. Of these, fifty-eight were from members of normal school, teachers college, or university faculties. One was from a supervisor of science in a large eastern city and five were from high school or academy teachers of science. On the basis of the judgments of these persons the attitudes and skills were ranked in the order of their importance.

The thirteen biology textbooks and the eight general science textbooks most frequently used in the schools of New Jersey were examined to find out what methods were used by the authors in treating the topic of scientific method, and which of the attitudes and skills rated as most important by the jury, were mentioned by the authors. In addition to these, copies of twelve new or revised editions of general science and biology

[1] Murchison, Carl, *A Handbook of Social Psychology* (Worcester Mass.: Clark University Press, 1935), p. 810.

[2] Webster's *New International Dictionary* (Springfield, Mass.: G. C. Merriam and Company, 1931).

books, published in 1934 and 1935, were examined in order to determine whether or not they differed from the older books in their treatment of this topic.

The methods used by the authors in treating the topic of scientific method were described, and a comparison was made between the rankings of the attitudes and skills treated in the textbooks, based on frequency of mention, and the ranking according to the judgments of the jury.

Findings

(1) There exists a substantial agreement among the science teachers responding to the questionnaire concerning the relative importance of the specific attitudes and skills which are involved in the scientific method. Sixteen of the twenty-nine attitudes and twenty-three of the twenty-five skills were considered important by eighty per cent or more of the judges. These sixteen attitudes are listed in Table I. The twenty-three skills are listed in Table II.

It can be seen from Table I that the attitude which impels one to revise one's opinions if the evidence warrants, or in other words, open-mindedness, and the attitude that it is necessary to be careful and accurate in what one does are considered important by every one who replied. The first of these also ranked first in a study of a somewhat similar nature, carried on by the Wisconsin State Science Committee.[3]

Table II shows that accuracy of observation and accuracy in recording data were considered important by the greatest number, having a rank of 1.5 each.

Open-mindedness, carefulness, and accuracy seem to be the outstanding elements in the scientific method according to the opinions of the judges in this study. These are followed very closely by a number of other elements as can be seen in Tables I and II.

(2) From a teaching point of view the average textbook of general science or biology is very poorly organized with respect to the topic of scientific method. Although many authors recognize the importance of the scientific method, as evidenced by statements in the preface, foreword, or in a separate chapter in the book, they have done little to organize the materials in their books so that the scientific method may be readily understood and made to function in the daily affairs of the student. Most

[3] Skewes, George J., "What is a Scientific Attitude?" School Science and Mathematics, Vol. XXXIII (Dec. 1933), pp. 964–968.

authors have apparently labored under the false assumption that the scientific method will be acquired as a concomitant

TABLE I

ATTITUDES RATED IMPORTANT BY EIGHTY PER CENT OR MORE OF THE JUDGES

Rank	Attitudes	Per Cent
1.5	One must revise one's opinion if the evidence warrants.	100.0
1.5	One must be careful and accurate in what one does.	100.0
3.	One's judgments must be as unprejudiced and impersonal as is possible.	96.7
4.	Nothing can happen without a cause.	95.1
5.	It is necessary to be systematic in the gathering and recording of data.	93.3
6.	One must hold one's conclusions as tentative and suspend judgment until all available facts are secured.	91.8
7.	Theories are often valuable because of the experiments to which they lead, even though they themselves are later disproved.	89.5
9.	One must be slow to accept as fact such statements as are not supported by convincing proof.	88.5
9.	One must view facts objectively.	88.5
9.	One must be free from dogma and superstition.	88.5
11.	The adequacy and appropriateness of one's data can be decided upon only as a result of careful reasoning.	87.7
12.	One should rely on facts.	86.9
13.	Man's conception of truth changes.	85.0
14.	It is necessary to plan prior to execution.	84.7
15.	One must recognize that all data are not of equal value.	83.3
16.	One must test all hypotheses against all available data.	81.0

TABLE II

SKILLS RATED IMPORTANT BY EIGHTY PER CENT OR MORE OF THE JUDGES

Rank	Skills	Per Cent
1.5	Skill in observing accurately.	98.3
1.5	Skill in recording observations accurately and orderly.	98.3
3.	Skill in forming independent judgments based on facts.	95.0
4.	Skill in distinguishing between fact and theory.	94.9
5.	Skill in picking out pertinent elements from a complex situation.	93.4
6.	Skill in recognizing errors and defects in conditions and processes.	93.2
8.	Skill in evaluating conclusions in the light of facts or observations on which they are based.	91.7
8.	Skill in isolating the experimental factor.	91.7
8.	Skill in forming sound judgments concerning adequacy of data	91.7
10.	Skill in synthesizing or putting together separate facts to form a conclusion.	91.5
11.	Skill in gathering data systematically.	90.2
12.5	Skill in planning an experiment to determine whether or not a proposed hypothesis is true.	90.0
12.5	Skill in evaluating data or procedures.	90.0
14.	Skill in recognizing omissions or deficiencies in situations.	89.5
15.	Skill in profiting from worth-while criticism.	87.7
16.	Skill in forming a reasonable generalization.	86.7
17.	Skill in arranging and classifying data in sequence and making conclusions obvious.	85.0
18.	Skill in applying general principles to new and concrete situations.	84.7
19.	Skill in recalling selectively items essential to a problem.	82.7

TABLE II (*Continued*)

Rank	Skills	Per Cent
21.5	Skill in locating problems.	81.7
21.5	Skill in disregarding irrelevant facts.	81.7
21.5	Skill in directing imagination into new and worth-while channels.	81.7
21.5	Skill in using the scientific instruments common in the laboratory.	81.7

of the subject matter of science without preparing definite learning situations which may lead to the development of an appreciation and understanding of the scientific method, and which will provide the student with opportunity to use this method.

It was noted that the more recently published textbooks of general science and biology devote more space to the scientific method than the older books do, and that they include such material in the body of the text rather than in prefaces and instructions to teachers.

(3) The correlation between the attitudes and skills considered important by the science teachers and the appearance of these attitudes and skills in the textbooks is not very significant. For the attitudes the coefficient of correlation is .06 and for the skills it is .45.

Of the six attitudes which were rated as important by ninety per cent or more of the judges, but three appeared in the upper quarter of a table showing the attitudes ranked in order of frequency of mention in the thirty-three textbooks. None of these three appeared in more than forty-five per cent of the books examined. These three were the attitudes concerned with carefulness and accuracy, open-mindedness, and cause and effect relationships.

Of the twelve skills considered important by ninety per cent or more of the judges, six appear in the upper quarter of a table showing the skills ranked according to their frequency of mention in the textbooks. Only one of these six appeared in more than fifty per cent of the books examined. The skill which was mentioned most frequently in the thirty-three books was the same one which was considered most important by the judges. This was, "skill in observing accurately."

SUMMARY

(1) This study has shown that there exists a significant agreement between the science teachers responding to the questionnaire concerning the specific attitudes and skills involved in the scientific method. Those attitudes and skills judged important by ninety per cent or more of the judges should probably be the ones for which learning situations should be provided in every high school science textbook and syllabus. On the assumption that agreement by ninety per cent of the judges is an indication of their extreme importance these are the ones which teachers in all grades should consciously strive to develop in all pupils so that they will function in their daily thinking.

(2) Although many authors recognize the importance of the scientific method they have done little to organize the materials in their books so that the scientific method may be readily understood and made to function in the daily affairs of the student. It would seem that in order to be effective in this respect a textbook should have numerous definite learning activities throughout the book which are designed to increase the students' familiarity with the scientific method and the attitudes and skills fundamental to it. The attention of the student must be specifically directed to the activities mentioned and these activities must be based on the subject matter of the chapter in which they appear.

(3) Although it has been shown[4] that there exists a significant agreement between the teachers of science concerning which attitudes and skills are essential to the scientific method, the authors of the textbooks examined failed to show a similar agreement. It would seem that the coefficient of correlation between the attitudes and skills which the science teachers consider important and the appearance of these attitudes and skills in the textbooks of general science and biology should be higher than .06 for the attitudes and .45 for the skills.

[4] See Tables I and II.

TOOTH PULP CONCERNED MAINLY WITH PAIN

The pulp, soft inner part of a tooth, is concerned mainly with painful sensations, Dr. Alton D. Brashear of Louisiana State University concluded after studying nerve structure in human and cat teeth. The organ of touch for the tooth, his studies showed, is probably located in the peridental tissues, which are between the root of the tooth and the socket in the jaw.

AN AVENUE OF SPECIAL INTEREST FOR JOHNNY Q. BEGINNER

By Charles H. Stone
Orlando, Florida

If any teacher of chemistry wants to see a student sit up and take notice, start him on a self-selected experiment or project in the laboratory. While his first choice is likely to be "The manufacture of nitroglycerine," a little skillful handling will direct his attention to such projects as; Pigments for paint; One or two simple dyes; Matches; The story of copper (or iron or lead); Preparation of a series of colored compounds of chromium (or lead or iron); Distillation of kerosene and gasoline from crude oil; Sprays and insecticides; etc. Care should, of course, be taken that the youngster does not undertake something which requires much more knowledge and skill in manipulation than he possesses. And, of course, the teacher will have to do some managing of the matter to insure good success. But these things have all been undertaken by my own students with very satisfactory results.

Let us take for example, copper. Johnny may begin by making a collection of maps showing the chief copper-producing areas of the world, or more particularly of the United States. He may write to the National Museum at Washington for small samples of copper ores which he may mount in some suitable manner and label properly. He may next begin with a sample of malachite. This ore, ground to a fine powder in an iron mortar, may be heated with expulsion first of any moisture and then of carbon dioxide. Copper oxide remains. This in turn may be reduced with hydrogen or illuminating gas with copper as the result. Small test tubes, $3 \times \frac{3}{8}$ inch may be used for displaying the different samples of material. The copper oxide may be treated with sulphuric or hydrochloric acids (dil) and the resulting copper sulphate or chloride crystallized. From solutions of copper sulphate he may produce by precipitation; copper chromate, copper phosphate, copper sulphide, etc. All of these filtered off and dried may be preserved in the small tubes. Double salts of copper and ammonia may be prepared and the peculiar cuprammonium sulphate, soluble in water but not soluble in alcohol, may easily be prepared. The bright red copper-mercury iodide, which turns black at temperatures above 70°C., is

not difficult of preparation. Copper plating may be done on a carbon pole taken from an expired dry cell. Altogether Johnny may dip into the chemistry of copper with increasing interest and pleasure until he has at his command a rather extensive idea of the chemistry of his chosen metal. And will he work on this? Try it and see!!

When all of this and much else has been accomplished, there comes up the question of making an exhibit of the work done. For this purpose, large sheets of cardboard may be obtained from the local printer; these come in size 22×28 inches and may be cut into quarters of 11×14 inches. Each of these cards may bear the title; "COPPER" with any suitable subtitle as; Sources, Mining, Transportation, Metallurgy: Refining, etc. On these cards the samples and the sample tubes may be affixed with a suitable legend accompanying each. The advertising pages of such magazines as *The Saturday Evening Post* or *Scientific American* may be ransacked for pictures, preferably in colors, which will serve to illustrate the topic. When completed, this exhibit will be a source of pride and satisfaction to Johnny and (this is confidential) to Johnny's parents.

At the recent Convention of Science Teachers of Florida, there was shown a series of such work, different projects by various students being on exhibition. It is believed by the writer that more attention to this sort of thing, without running too largely in this direction, would result in an increased interest and a raising of grades in the work done by students beginning chemistry. The tangible results are always more attractive to young people than are the more elusive and apparently unrewarding results obtained when such intangible products as the gases are the sole product of individual laboratory work.

NEW VITAMIN REPORTED DISCOVERED IN HUNGARY

A new vitamin, designated with the letter "P" by its Hungarian discoverers, is reported by the American Chemical Society in its technical journal, *Industrial and Engineering Chemistry*.

Vitamin P appears to be closely related to vitamin C and, like the better known substance, is found in lemons and paprika. Prof. A. Szent-Gyorgyi of Szeged University, Hungary, who discovered ascorbic acid, is credited with the new find.

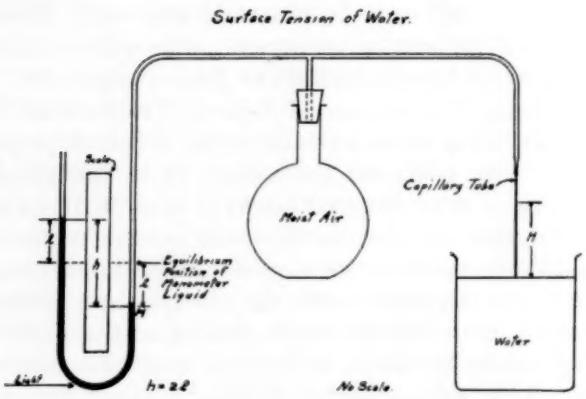
The exact chemical nature of vitamin P is now being studied but already it appears to consist of a very large molecule containing either 81 or 83 atoms of carbon, hydrogen and oxygen. The compound is said to decrease the permeability of cells to albumin and for this reason is supposed to have vitamin-like properties. The new substance appears to be a natural companion of vitamin C in plants.

SURFACE TENSION OF WATER

By W. Irwin Thompson
Los Angeles Jr. College, Los Angeles, California

It is not intended to give a discussion of the theory of capillarity. Rather it is the purpose of this article to describe an efficient method of counterbalancing the pressure which causes liquids to rise in capillary tubes. The procedure of admitting water into one arm of the manometer, to balance this pressure, making use of a water dropper, has insurmountable difficulties familiar to those persons having used this method.

A piece of barometer tubing may be heated uniformly in the flame of a Fisher burner, then drawn to capillary size with a diameter approximately 0.02 cm. The tubes used were afterward filled with mercury and the bore was found to be uniform in its diameter, throughout the fractional part of the length the



water normally rises. The diameter of the bore was measured, using a comparator reading directly to 0.0005 cm.

A glass tee may be inserted in the rubber tube which connects the capillary tube with the manometer. This tee may be connected, by means of a one-hole rubber stopper, to a 250 c.c. flask. Please refer to the figure.

When lowering the capillary tube, to make surface contact with the distilled water in the beaker, the stopper may be left out of the flask. The act of inserting the stopper produces some pressure, which forces the water meniscus in the capillary tube downward. The additional pressure, necessary to force the

meniscus in the capillary tube to the level of the water surface in the beaker, is produced by grasping the flask with the hands. The blood heat is sufficient to increase the mean kinetic energy of the molecules within the flask and connections, and thereby produce the pressure.

To make the apparatus more sensitive put some water, below room temperature, into the flask to cool it. Shake most of the water out of the flask before connecting it to the air line again. The pressure will be greatest, within the flask and connections, if the flask is cupped with your hands. The pressure variation can be controlled at will by changing the distance between the flask and the hands.

The depressed liquid meniscus, in the manometer must be followed, preferably, with a celluloid straight edge, as the pressure is produced within the system, and a reading of the scale obtained at the instant the water in the capillary tube reaches the level of the water in the beaker. If any air escapes from the lower end of the capillary tube, the stopper must be removed from the flask and the process of producing pressure repeated.

Place some chemical solution, for cleaning glassware, in the manometer an hour before the apparatus is to be used. Then remove the solution and wash the manometer with distilled water. Then the meniscus in each arm of the manometer will stand at the same elevation, when the liquid is put in it. If there is an outside window in the laboratory, daylight may be admitted to the bottom of the manometer and the meniscus will assume the appearance of a crescent moon, due to the effect of light reflected up one arm of the manometer. Then it will be easy to follow the meniscus with a straight edge as it is forced downwards. A few minutes trial will show the proper orientation of the manometer to give the best illumination of the meniscus.

POISONOUS SUBSTANCES IN BLOOD FOLLOWING EXTENSIVE BURNS

The general intoxication or poisoning which follows an extensive burn and may result in shock and death is actually due to poison in the blood, it appears from studies reported by Dr. Sol Roy Rosenthal of Chicago at the meeting of the American Association of Immunologists.

The poisonous substance, or toxin, was found in the blood after severe burns and an antitoxin which neutralized this substance was found in the blood after recovery from the burns. The poisonous substance makes the walls of small blood vessels more permeable so that blood plasma may leak through and the blood flow through these small vessels is retarded.

APPLICATION OF PROFESSIONAL TREATMENT TO THE QUADRATIC FUNCTION

PART II

BY EUCEBIA SCHULER

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THE HISTORY OF THE QUADRATIC FUNCTION

Two of the most natural questions to arise in connection with the history of the quadratic function are: what caused the development of the quadratic equation, and of what use has it been to the world? "The first known solution of the quadratic equation is the one given in the Berlin Papyrus . . . ,"[1] which is believed to have been written between 2160 and 1700 B.C. The problem in question gave rise to a quadratic and a linear equation, both in two unknowns; the solution was probably derived by the rule of false position.[2] It is also believed that Euclid (*c.* 300 B.C.) had a knowledge of quadratic equations and their solutions.[3] Greek investigations in proportion led to the second degree equation as shown by the following:

$$a:x=x:b$$

$$x^2=ab$$

The duplication of the cube resolved itself into the problem of finding the mean proportionals between two lines; for example, $a:x=x:y=y:2a$. From these proportions the following equations resulted:

$$x^2=ay,\ xy=2a^2,$$

eliminating y, it is found that

$$x^3=2a^3.$$

The early solutions were based upon geometric constructions and were applicable only to particular situations. It was not until the time of Descartes (1637) that a general theory was derived explaining the nature of the solution, and showing that every equation represents a geometric locus and *vice versa*. Out of the latter concept grew the fact that all quadratic functions are algebraic representations of conic sections.

[1] D. E. Smith, *History of Mathematics*, New York, Ginn and Co., 1925, *2*, 432, 443.

[2] Ibid., 443–444.

[3] Smith, *op. cit.*, *2*, 444. See also Vera Sanford, *A Short History of Mathematics*, New York, Houghton Mifflin Co., 1930, 166. W. W. Beman and D. E. Smith, *Translation of Fink's History of Mathematics*, Chicago, Open Court Publishing Co., 1903, 79.

The Hindus, possibly as early as 500 B.C., could solve the equation $ax^2+bx=c$ algebraically, but no rule for the solution has been found. It has been fairly recent that $ax^2+bx+c=0$ has been used for the general type of a quadratic equation where a, b, and c can be positive or negative. Even up to the 17th century $x^2+px=q$ and $x^2-px=q$ were considered different types.

Sridhara (*c.* 1025) probably gave the so-called Hindu Rule for completing the square but the negative root was neglected.[4]

Vieta[5] (*c.* 1590) used a unique method of reducing a general quadratic to an incomplete quadratic by making the substitution $x=u+z$ and $z=-\frac{1}{2}a$. He also used a method of approximations which presents in a simple interesting way the concept of small quantities of different orders and sets forth a principle of calculus. The values of the process are that it is self-correcting, it may be applied to numerical equations of any degree, it may be easily used in extracting roots of equations of the type $x^n=a$, and it may serve as an introduction to Horner's method of solving equations.

For those who have had trigonometry in high school a trigonometric solution[6] of the quadratic equation and a graphic solution of complex roots will be interesting as the former gives the solution in terms of a function of some auxiliary angle.

After this brief historical sketch, many topics for outside reading and further study may be proposed; a few examples follow:

1. The arithmetic solutions of the quadratic equation by the Egyptians.
2. The geometric solutions of the quadratic equation by the Greeks.
3. The use of the quadratic equation in physical sciences, social sciences, and artillery.
4. Solving the quadratic equation on the slide rule.
5. The aesthetics of the quadratic.

HISTORY OF THE TEACHING OF QUADRATICS

The history of the teaching of this topic in college algebra can probably be studied best through an examination of textbooks of the different periods. Literature on the pedagogical aspects

[4] Smith, *op. cit.*, *2*, 446.

[5] Smith, *op. cit.*, *2*, 449. J. W. A. Young, *Monographs on Modern Mathematics*, New York, Longmans, 1927, 229. Benchara Branford, *A Study of Mathematical Education*, London, Oxford at Clarendon Press, 1924, 219–220.

[6] See Johannes Tropfke, *Geschichte Der Elementar-Mathematik*, Berlin, Walter De Gruyter and Co., 1922, *3*, 53. J. A. Serret, *Traité de Trigonometrie*, Paris, Gauthier-Villars, 1900, 80–83. William Chauvenet, *A Treatise on Plane and Spherical Trigonometry*, Philadelphia, J. B. Lippincott and Co., 1875, 95–96.

of special topics or on the general field of college algebra seems to be almost entirely lacking. Algebra did not become a part of the college curriculum until the early part of the 18th century. Conics and fluxions in some cases appeared before algebra. An examination of some texts[7] which were published about the middle of the 19th century shows that the general quadratic equation of today was given in four different forms in order to take care of the variations in the signs of the coefficients. In a textbook by Aldis[8] in 1887 is given the general quadratic equation as used now; there is also included a discussion on the symmetry of the roots.

The usual method of handling topics in the old books may be summed up in these steps: definitions, rules, statement of properties, exercises and problems. There were no illustrations, no explanations, no graphs and no special helps for students or teachers. The methods of solution included factoring, completing the square, the Hindu method of completing the square, and the formula. A discussion of the properties of the roots and applications to verbal problems usually followed in the texts examined. There is no definite sequence of topics found in either the old or the new texts. It is interesting and encouraging to note, however, that in spite of all the poor teaching ascribed to those fifty or seventy-five years ago one may occasionally see an effort toward improvement in teaching that is rather convincing. Those teachers were struggling with the same problems with which instructors are concerned today.

There seems to be a tendency in most of the more recent texts to begin the study of the quadratic equation with the factor method. This may be explained on the basis of a psychological approach by using the easiest method first.

Some of the teaching problems which may be profitably studied by freshmen, which may help clarify their thinking, and which may lead to a more thorough mastery of the subject are suggested:

1. Make a set of 10 quadratic equations, graded from simplest to more complex, that would be suitable for introducing the study for the first time.
2. What material in this topic is adaptable to high school teaching and why?

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[7] See George Peacock, *A Treatise on Algebra*, London, Cambridge University Press, 1845, *2*, 77–95. Joseph Ray, *Algebra for Colleges, Schools and Private Students*, Cincinnati, Sargent, Wilson, and Hinkle, 1852, 186–212.

[8] W. Steadman Aldis, *A Text Book of Algebra*, New York, The Macmillan Co., 1887, 244–268.

3. On what mathematical processes does the study of the quadratic depend?
4. How would you justify, to a high school student, the process of setting each factor equal to zero in solving for the values of the unknown?
5. Examine five high school or college texts and decide which one presents the quadratic function best and why.

AN INTRODCUTION TO THE QUADRATIC FUNCTION

The quadratic function treated in its entirety may include an introductory study of rational, irrational, and imaginary numbers followed by the general quadratic function of the type

$$ax^2+by^2+cxy+dx+ey+f \qquad (1)$$

which would include all conic sections, transformation of coordinates, polar coordinates, tangents, normals, and so on. Then simultaneous quadratic equations, radical equations, equations of the quadratic type, and verbal problems may be added to give a complete treatment; but in order to preserve the significance of a unit this discussion will be limited to the parabola of the type

$$y=ax^2+bx+c. \qquad (2)$$

Such questions as the following should be studied in this connection:

1. What is the meaning of the word *quadratic?*
2. Why is y said to be the single valued variable?
3. Why is x said to be the double valued variable?
4. Which variable is independent? Dependent? Why?
5. What limitations, if any, are placed on the coefficients a, b, and c?
6. What relation does this equation have to (1)?

The quadratic function is very important from the standpoint of scholarship, preparation for more advanced work and practical applications. Functions of the quadratic type arise from problems in physical sciences; frequently they develop from questions of distance, time, velocity, and area. One of the most well known is

$$s=\tfrac{1}{2}gt^2$$

where s represents the distance an object falls, t the time in falling, and g the constant acceleration due to gravity. This formula applies when the object falls without initial velocity and when the only force acting is gravity. The equation of the path of a projectile in a vacuum is $y=(g/2v^2)x^2$ derived from $x=vt$ and $y=\frac{1}{2}gt^2$ where v equals the velocity, g the force due to gravity, and t the time.

The graph of a quadratic function of type (2) is always a

parabola which is a significant and interesting curve. If the resistance of the air is neglected the path of a projectile is a parabola, and the stream of water as it comes from a hose travels in a parabolic curve. When a cylinder containing a liquid is rapidly turned a cross section of the surface of the liquid is a parabola.[9] The arches of a suspension bridge; cross sections of auto headlights, searchlights, and reflecting telescopes; and the reflecting walls about the stage of an auditorium are in parabolic form.

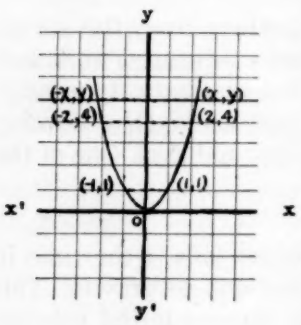
The right member of the equation

$$y = ax^2 + bx + c$$

is said to be a *complete* or general quadratic function of x and $ax^2 + c$ a *pure* quadratic function of x. The different forms of the quadratic function of x may be expressed as follows where a, b, and c are different from zero:

$$y = ax^2$$
$$y = ax^2 + c$$
$$y = ax^2 + bx$$
$$y = ax^2 + bx + c$$

The graph of the quadratic presents opportunities for visualizing many properties of the function and affords an almost unlimited field of study that leads into the analytic geometry and the calculus. One of the most important topics in this connection is that of maximum and minimum values. An excellent place to lay the foundation for advanced work and to prepare for future curve tracing is in the study of the graph of the quadratic function. Other properties to be emphasized are the nature of the roots, the number of roots, the zero values and the various changes of the function as certain conditions are imposed on the coefficients. First, consider $y = ax^2$, where $a = 1$, and the graph of the equation is shown in figure 1. Students should be led to see the behavior of y as x



$y = x^2$

FIG. 1

[9] Georg, Wolff, "The Mathematical Collection," *The National Council of Teachers of Mathematics, Eighth Yearbook*, New York, Bureau of Publications, Teachers College, Columbia University, 1933, 219–223.

increases in the positive and the negative directions, and to note the values of each variable as the other is zero. The table of values and the graph show symmetry with respect to the y-axis. Such facts as the relation between the line of symmetry and the axis of the parabola, the vertex, and the minimum point should be studied.

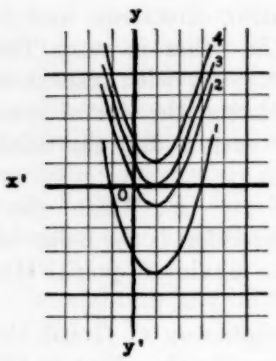
Next plot the curve represented by $y=-x^2$. What effect does the negative sign have on the curve? What is the behavior of the function as x changes? What is the maximum point? Has the line of symmetry been changed?

Now try the effect of a constant multiplier on x^2. Graph the function $y=ax^2$ when $a=-\frac{1}{2}, \frac{1}{2}, 1, 2$. Describe the effect on the curve of the change in the coefficients.

Compare the equations $y=ax^2$ and $y=ax^2+c$ and decide what change in the curve will be obtained when a positive and a negative c is added to the function. Consider a specific case such as $y=2x^2+4$, $y=2x^2$, and $y=2x^2-1$, graph the curves and see if your conclusion was correct. In like manner the student may make a study of the graph when the function is $y=ax^2+bx$ and determine the effect of the addition of the first degree term with negative and positive coefficients. Finally the same kind of analysis is applied to the general quadratic $y=ax^2+bx+c$, and a summary made of all the changes in the curve corresponding to the change in the coefficients. One may even use the calculus in teaching the maximum and minimum values, but if this is not desired the points may be found approximately from the graph or from the discriminant.

METHODS OF SOLUTION

The Graphic Method. Further analyses of the function and its graph may be brought out by considering the equation $y=x^2-2x-3$ and investigating the zero values, intercepts, real values, and excluded values. The zeros of the function because of their importance and use in advanced work should receive special attention. Such questions as: What is the effect on the zeros of the function when the constant is changed? What is the nature of the roots when the constant is zero? What does the addition of a positive number greater than 3 do to the roots? Then summarize these observations by telling under what conditions there are two real distinct solutions, two equal solutions, or two imaginary solutions.



(1) $y=x^2-2x-3$
(2) $y=x^2-2x$
(3) $y=x^2-2x+1$
(4) $y=x^2-2x+2$

FIG. 2

Just at this point is a chance for some creative work on the part of the students. The general quadratic equation may be experimented with and a series of graphs made by holding a and b constant and letting c vary, by holding a constant and letting b and c vary, etc. In this way the student may work out a set of discoveries for each stated condition. If these graphs are done in colors they make very helpful and interesting studies. Other problems which may be proposed are:

1. Under what conditions would the axis of the parabola be parallel to the x-axis?
2. What differences would this position of the parabola make in the zeros, the maximum and minimum points, etc.?

While analyzing the graph of the function an outline of the steps in the procedure can be set up which will greatly simplify the work and lay a splendid foundation for analytic geometry. Such an outline may be similar to the following:

1. What are the intercepts?
2. Does the curve have a maximum or a minimum point? What is it?
3. What is the axis of symmetry?
4. How does the curve change as x changes?
5. What are the excluded values?
6. What is the solution? Is it real or imaginary?

The question of symmetry is one that furnishes a desirable background for further work in advanced courses and presents an opportunity for teaching the aesthetic properties of the equation.[10] There is in this connection the idea of order, composition, rhythm, harmony, and unity.

Factoring. "The first important treatment of the solution of quadratic and other equations by factoring is found in Harriot's *Artis Analyticae Praxis* (1631);[11] even as late as this the author ignored the negative roots. One of the points of difficulty often encountered by the student in the factor method is the reason for setting each factor equal to zero in order to solve for the

[10] See J. B. Shaw, "A Chapter on the Aesthetics of the Quadratic," *The Mathematics Teacher* (1928) *21*, 121–134.

[11] Smith, *op., cit. 2*, 448–49.

unknown. Understanding the *why* of this procedure gives a good reason for checking every value of the equation.

Completing the Square. The method of completing the square has an interesting geometrical background. The Greeks were able to solve the quadratic equation by this method and Al-Khowarizmi (*c.* 825) developed two constructions for completing the square based on the Greek models. The simpler of these two constructions is frequently given in modern high school texts. Students who are not familiar with them will find them valuable contributions to their knowledge. The importance of the above method lies in the fact that it is used to develop the general formula.

The Formula. The value of the formula as a means of solving any quadratic equation should be emphasized. The difficulties usually encountered in the development and application of the formula are:

1. Confusion about the meaning of the "transposition of terms."
2. The reason for adding one half the coefficient of x to both sides of the equation.
3. The recognition of two roots instead of one.
4. The putting into type form of equations like
$$ax^2+10x+c+2x^2-2bx-1=0.$$

It would seem that such a simple operation as this would need no particular attention but it has been the writer's experience that many freshmen need instruction on this point.

5. The dividing by a common factor containing the unknown.

The formula gives the solution for any quadratic equation in terms of its coefficients. The properties of the roots need special attention. It will be a good exercise for the students to summarize these properties in table form with illustrative examples and to compare the discriminant and graphic methods of determining the nature of the roots.

Another phase of the nature of the roots may be studied by starting with the general equation $ax^2+bx+c=0$ and obtaining results which follow as a consequence of setting b and c equal to zero, separately and at the same time. This may be proposed as a problem with the further question: why must a be different from zero? These conditions can also be seen geometrically by means of the graph. In this connection an interesting study is to let $a+b+c=0$ and examine the roots of the equation under all possible arrangements of the coefficients.[12]

[12] Herman T. R. Aude, "If $a+b+c=0$," *The Mathematics Teacher* (1931), *24*, 491.

After having studied the nature of the roots there naturally follows the discussion concerning the symmetric functions. Students may easily develop formulas for the sum and the product of the roots from the general formula. Here again is an opportunity for originality. The teacher may suggest that certain conditions be imposed on the sum and on the product of the roots, that the equations be derived fulfilling these conditions, and that the effect of these conditions on the coefficients be determined.

As an assigned problem a student might be asked to set up a plan for teaching a high school student how to find the roots of a quadratic equation without using the four methods previously discussed.

It is a good thing, especially for those who major in mathematics, to learn to handle analytic proofs of general theorems. The proof of the theorem that a quadratic equation has two roots is very simple and may be understood by most students.

If the elements of the calculus are previously taught the opportunities for enriching the study of the quadratic are extended. Pupils should study such questions as those concerning the relation between the values of x and slope of the curve, the relation between the slope of the curve and its maximum and minimum points, the direction of the curve, the vertex, and the axis. From the derivative of a general quadratic of the form

$$y=ax^2+bx+c$$

may be developed formulas for the maximum and minimum points, the vertex, and the axis. From this point a study of tangents naturally follows, and some students may be interested in comparing methods of finding tangents with and without the aid of calculus.

Students in mechanical drawing would enjoy and profit by a study of the mechanical construction of parabolas. Without more of the analytical geometry and the definition of a parabola, however, the means of mechanical construction are limited. One of the simplest methods is the rectangular construction used sometimes by engineers. If it is desired to construct a parabolic arch of a certain width and height it may easily be constructed by the use of a rectangle and straight lines which divide one half the length of the rectangle into n equal parts and the width into n equal parts. The points of division of the width are then joined to the center point of the length and the intersections of the first radiating line with the first ordinate

line, the second radiating line with the second ordinate line, etc., are points of the parabola. This may be proved by simple geometry.[13]

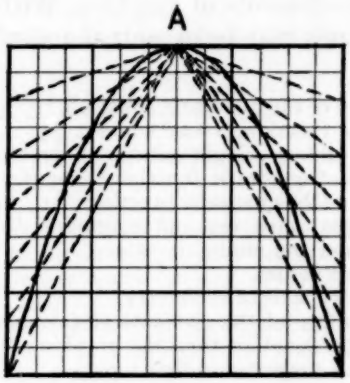


FIG. 3

A few illustrations of problems for further study are suggested as follows:

1. Study the article, "The Quadratic Equation" by Howard F. Fehr in *The Mathematics Teacher* (1933), *26*, 146–149, and present this interesting study of the quadratic equation by using the form
$$x^2-2px+p^2-q^2=0.$$
2. Find the tangent to a parabola by Descarte's Method. (W. L. Miser, "Descarte's Method of Tangents," *The Mathematics News Letter* (1933), *7*, Nos. 7–8.)
3. Prove that the quadratic equation has no more than two roots.
4. Make a "source book" of all the parabolic forms that you can find, illustrate with pictures and show how you would use these in teaching a high school class.
5. Make a collection of problems, arising in practical life, which employ the quadratic equation for a solution.
6. Construct a parabola by mechanical means.

Practically all of the points of professional treatment suggested for freshman mathematics in Part I have been illustrated in the unit on the quadratic function. An attempt has been made to "focus instruction under the guidance of professional attitude," and "to thoroughly integrate the *what* with the *how* and *why*."

It will usually be impossible to conduct such an extensive study of college algebra as is suggested in the unit on the quadratic function, but some of the suggestions can be carried out

[13] Currier and Watson, *op. cit.*, 119. For other mechanical constructions of the parabola see Wolff, *op. cit.*, 219–223. Most textbooks on analytical geometry give suggestions for constructing the parabola.

and certain minimum essentials should be emphasized. It is assumed that the student has had a thorough knowledge of elementary algebra including rational, irrational, and imaginary numbers, and the elements of graphing. With this background the work of this unit may be organized according to the following outline:

I. A brief history of the quadratic equation.
II. The quadratic function, $y=ax^2+bx+c$.
  1. Definition and use, single valued and double valued functions.
  2. Two kinds of quadratic functions—complete and incomplete.
  3. The graph of the quadratic function.
    a. Intercepts; zeros, real and imaginary; directions of the curve.
    b. Maximum and minimum values.
    c. Excluded values.
    d. Symmetry, axis of symmetry.
    If the study of the elements of calculus should precede the quadratic function then the graphic study may include the materials suggested in that topic.
  4. Methods of solution.
    a. The graph.
    b. Factoring.
    c. Completing the square used chiefly to develop the formula.
    d. The formula.
      (1) Nature of the roots.
      (2) Symmetric functions of the roots, including the sum and the product of the roots.

In connection with the suggested outline the instructor should call attention to the special difficulties mentioned in the unit; the educational values, such as preparation for future work, appreciation, habits, skills, and method of thinking; and occasional special topics or reports on the history of the subject.

There is no limit to the desirable information which will aid in making teachers of mathematics more efficient and it is the opportunity and the privilege of instructors in teachers colleges to enrich as much as possible the courses given to these prospective teachers.

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MAGNETIC FIELDS ON PHOTOGRAPHIC PAPER

BY A. C. DAUGHERTY, *Township High School, Casey, Illinois*

An interesting variation in the familiar experiment of making blue prints of the various magnetic fields with iron filings is to use photographic paper instead of blue print paper. Not only is it a variation but a clearer and sharper print is obtained than with blue print paper. This method also offers an opportunity to introduce some elementary photography if the instructor so desires.

The procedure is the same as that of making the blue prints except that photographic materials are used. For the experiment you need a dark room, a ruby safelight, photographic paper, developing and fixing solutions. A contrast, bromide paper, five by seven inches or larger may be used. Better results are obtained if the magnets are placed under a glass plate and the filings sifted on until they give a good field. Then, without disturbing the filings, the glass plate is placed over the photographic paper and the paper exposed. An exposure of approximately five seconds with a sixty watt lamp at a distance of two feet is usually sufficient. A trial or two will determine the correct exposure. The paper is then developed in any standard developing solution and fixed in the standard acid hypo bath.

This same procedure may be used to make lantern slides of magnetic fields by substituting sensitized lantern slide plates for the paper and using smaller magnets.

A BOTANICAL GARDEN. ECOLOGICAL GROUPS

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The purpose of the botanical garden herein described is to provide material for a study of ecological groups. All the plants discussed, whether native or foreign to a given region, are unmodified by cultivation, and all are perfectly hardy in the latitude of Chicago. To prevent this paper from becoming unduly long only a few characteristic plants are cited. If more are wanted recourse should be had to various dealers' catalogues, sent free on request. A list of dealers will be found at the end of this article. There are no illustrations, for the main reason that excellent figures, some in color, can be had in great profusion from many of the catalogues above mentioned.

It is often thought that trees and shrubs should be planted in spring before the leaves appear, and herbaceous plants in the autumn. This may be true in some cases, especially regarding the plants with bulbs, nevertheless a great many things can be planted through the growing season, and with proper care they will do well.

If, when the garden is first made, there is not enough shade, due to the small size of the trees or some other factor, then some quick-growing annual with broad leaves is very helpful. If large annuals are desired there is no better than the Common Sunflower (*Helianthus annuus*), seeds of which are obtained most anywhere. If smaller plants are needed the Buckwheat (*Fagopyrum esculentum*) is excellent, and seeds of this are likewise very easily obtained. Of course, a shelter could be constructed of lath or in some other way, but such devices are very unsightly.

Evergreen (Coniferous) Woods: This group will need a light, well-drained and highly acid soil. A find sand, with a humus obtained from the leaves of conifers, such as a pine, is excellent. A leaf mold collected from old rhododendron beds may be purchased from Gardens of the Blue Ridge. Considerable shade will be needed, but the trees should not be planted too near together, as the result is liable to be twilight under them even in midday, and this is much too dark. The trees, with one exception, are all evergreen. Such are the Hemlock (*Tsuga canadensis*), Arbor Vitae (*Thuya occidentalis*), Red Cedar (*Juniperus virginiana*), Douglas Spruce (*Pseudotsuga taxifolia*), and the White Pine

(*Pinus strobus*). A deciduous tree, the American Larch or Tamarack (*Larix laricina*), may well be included, though in the southern part of its range it is not likely to be found except in bogs. It is a conifer like the evergreen trees mentioned. Under the trees should be planted such evergreen coniferous shrubs as the American Yew (*Taxus canadensis*), and the Common Juniper (*Juniperus communis*). A few deciduous shrubs will be found in such woods, as a species of Sumac (*Rhus canadensis*), with three-foliolate leaves and red berries. Unlike its relatives the Poison Ivy and Poison Sumac it is entirely harmless. Occurring also, though not restricted to this habitat, are a species of Honeysuckle (*Lonicera dioica*), and the Maple-leaved Viburnum (*Viburnum acerifolium*). Evergreen herbs include species of Club Moss (*Lycopodium*), among which may be specially recommended the Running Pine (*L. clavatum*), which trails to sometimes six feet or more, the Ground Cedar (*L. complanatum*), which in general appearance resembles the Arbor Vitae or White Cedar, and the Ground Pine (*L. obscurum*), which resembles somewhat a small pine; this species is much used in Christmas decorations. Other evergreen herbs are the Rattlesnake Plantain (*Epipactis pubescens*), an orchid with white-veined leaves, a Blue Violet (*Viola conspersa*) with long leafy stems, Prince's Pine (*Chimaphila spp.*) Shin Leaf (*Pyrola spp.*), Checkerberry (*Gaultheria procumbens*), the last three small erect plants of the Heath Family, the trailing Bearberry (*Arctostaphylos Uva-ursi*), likewise a Heath, and the Twin-flower (*Linnaea borealis americana*). A few deciduous herbs occur, as the Stemless Lady's Slipper (*Cypripedium acaule*), and the Wood Betony (*Pedicularis canadensis*), with yellow flowers in early spring. Found also are mosses such as *Hypnum*, a yellowish much-branched species of trailing habit, *Mnium*, likewise a trailer, but with greener leaves and much less branching, Pine-tree Moss (*Climacium americanum*), resembling a miniature pine tree, and a Haircap Moss (*Polytrichum juniperinum*), growing in very dense clusters, one of the cushion plants.

Deciduous Woods: This group is divided into two sections:

(*a*) *Dense Woods:* This is the type of woods represented by the beech-maple forest common in the eastern states. The soil is rich in humus, and somewhat acid, and there is dense shade. Common trees are the American Beech (*Fagus grandifolia*), Hop Hornbeam (*Ostrya virginiana*), Sugar Maple (*Acer saccharum*), Basswood (*Tilia americana*), and the Tulip Tree

(*Liriodendron tulipifera*). On account of the heavy shade the shrubby undergrowth is not abundant, but there may be found such forms as the Maple-leaved Viburnum (*Viburnum acerifolium*), already noted as occurring in the evergreen woods, Spice Bush (*Benzoin aestivale*), Witch Hazel (*Hamamelis virginiana*) a Honeysuckle (*Lonicera canadensis*), and an Elder (*Sambucus canadensis*). Perennial vines are represented by the Dutchman's Pipe (*Aristolochia macrophylla*) and the Trumpet Flower (*Tecoma radicans*), while a good example of an annual vine is shown by the Wild Balsam Apple (*Echinocystis lobata*), a member of the Gourd Family. Deciduous herbs include such forms as Jack-in-the-Pulpit (*Arisaema triphyllum*), Dog's-tooth Violet (*Erythronium spp.*), bulbous plants with two species common in the east and several in the west, Trillium (*Trillium spp.*), among the easiest grown of plants, May Apple (*Podophyllum peltatum*), Dutchman's Breeches (*Dicentra cucullaria*), and the Common Blue Violet (*Viola cucullata*). A good evergreen herb is the Common Periwinkle (*Vinca minor*), a trailing plant with blue flowers. Many ferns are common here, evergreen species being the Common Polypody (*Polypodium vulgare*), Lady Fern (*Asplenium filix-femina*), Christmas Fern *Polystichum acrostichoides*), a Spleenwort (*Asplenium trichomanes*), and the Walking Leaf (*Camptosorus rhizophyllus*). The last two seem to require limestone, easily supplied by inserting a few pieces of rock in the soil; this rock need not appear above the surface unless desired. Two good representatives of deciduous ferns are the Maidenhair (*Adiantum pedatum*) and the Bladder Fern (*Cystopteris bulbifera*). A Club Moss (*Lycopodium lucidulum*) is often found, and is easily grown. Mosses are common, *Hypnum*, *Mnium* and others. A species of Liverwort (*Conocephalus conicus*) may be found. The lichens are mostly those of the foliose (leafy) type.

(*b*) *Open Woods:* This group is represented in nature by the oak-hickory forests prevalent in the central states. Here there will be found a well-drained, somewhat acid soil, considerable leaf mold, and partial shade. Due to the more open habitat shrubs are much more frequent than in the dense woods. Of trees there are many oaks, among which might be mentioned the White Oak (*Quercus alba*), with deeply lobed leaves and elongated acorn with shallow involucre (cup), the Chestnut Oak (*Q. Muhlenbergii*),with merely toothed leaves and rounder acorn with deeper cup, and the Laurel or Shingle Oak (*Q. im-*

bricaria), with entire leaves and globose acorn, the cup covering it about one-half. Some species of Hickory should also be included, since this is a characteristic tree of such situations. The Shell-bark Hickory (*Carya ovata*) and the Pignut (*C. glabra*) are especially common. Other trees, usually smaller in size, are the Osage Orange (*Maclura pomifera*), Sassafras (*Sassafras variifolium*), the Bird Cherry (*Prunus pennsylvanica*), and the Catalpa (*Catalpa bignonioides*). Shrubs are numerous, including such forms as the Hazel (*Corylus americana*), Crabapple (*Pyrus coronaria*), Hawthorn (*Crataegus mollis*), and the Hop Tree (*Ptelea trifoliata*). Vines, too, are common, woody specimens being the Bittersweet (*Celastrus scandens*), Wild Grapes (*Vitis spp.*), and the Virginia Creeper (*Ampelopsis quinquefolia*), while herbaceous vines are represented by the Ground Nut (*Apios tuberosa*), a legume with tuberous thickenings below ground. The herbs are largely of the early flowering type, as the Spring Beauty (*Claytonia virginica*), the Early Buttercup (*Ranunculus fascicularis*), Downy Yellow Violet (*Viola pubescens*), and a species of Trillium (*Trillium recurvatum*). Among the bulbous plants the Lily Family is well represented, being specially common in the far west, and including such worthwhile members as species of *Brodiaea*, *Calochortus* (particularly the Globe Tulips *C. albus* and *C. amabilis*), and *Fritillaria*. All these herbs die down before winter sets in. Two evergreen herbs are the Hepatica or Liverleaf (*Hepatica triloba* or *H. acutiloba*), with lobed leaves and anemone-like flowers in earliest spring, and the Everlasting (*Antennaria plantaginifolia*), an early-flowering Composite with woolly leaves. Plants flowering later than the above mentioned are not very common, and comprise mostly forms of Goldenrod and Aster, blooming in late summer and autumn. Ferns are not uncommon, including the Beech Fern (*Phegopteris hexagonoptera*) and the Brake (*Pteris aquilina*), both of these deciduous, and the Ebony Spleenwort (*Asplenium platyneuron*), an evergreen. The Little Club Moss (*Selaginella rupestris*) may often be found, especially on exposed rocks. Mosses are much fewer than in thick woods, and are mostly restricted to cushion plants, growing in very dense clusters; among them are the Purple-stemmed Moss (*Ceratodon purpureum*) fruiting in early spring, and easily recognized by its purplish stem, and the White Moss (*Leucobryum glaucum*), a large pale moss with special cells for absorption of water. It never seems to bear fruit. Of the Liverworts *Porella*, a leafy

species looking somewhat like *Mnium* among the mosses, may be induced to grow on the north side of trees near the ground. The lichens include all the three types, *crustose* on rocks, etc. in the sunnier places, *foliose* in the more shaded areas, and *fruticose* (especially species of *Cladonia*) likewise in areas which are likely to be at least partially shaded.

Pond and Swamp: The pond can very well be constructed at the edge of the deciduous woods, thereby having some shade and at the same time adequate sunshine. The trees, however, though losing their leaves in autumn, do not belong to the deciduous woods, but are in reality amphibious forms peculiar to this habitat.

It will probably be necessary to construct an artificial pond. The type easiest to make is one with an earth bottom. If a small stream is available it can be readily dammed to form a pond, otherwise a pit can be dug deep enough to reach clay, possibly two feet, or clay can be brought in and well tamped on both sides and bottom. On this clay about six inches of good garden soil should be laid down. A compact soil will need less clay; a highly porous soil will require six inches, well worked until plastic. A pond two feet deep is ample for any hardy aquatics. A thin layer of sand spread over the soil will help to keep the water clear. Another pond, easily made, is to sink a wooden tub in the ground, with six inches of rich soil and sand on top as in the preceding example. Tubs of white cedar, especially made for this purpose, can be purchased of William Tricker, Inc. This same firm has a portable pool which is much larger than the ordinary tub, being 7 feet, 7 inches long by 4 feet, 7 inches wide. Besides the types of pond above mentioned there are concrete devices both formal and informal. They are described in the catalogues of dealers in aquatics, as are the other sorts.

In the center of the pond should be planted the Water Lilies, such as the Cow Lily or Spatterdock (*Nymphaea advena*), the Sweet-scented Water Lily (*Castalia odorata*), the Tuberous Water Lily (*C. tuberosa*), and the Water Shield (*Brasenia Schreberi*). All of these have floating leaves borne on long petioles. The American Lotus (*Nelumbo lutea*), with enormous leaves and flowers raised high above the water, belongs here, but must be planted by itself, otherwise it will soon crowd out the others. Outside the water lily zone and in somewhat shallower water may be placed the plants which are rooted in the soil and

entirely submerged, as the White Water Crowfoot (*Ranunculus aquatilis*) and a Water Milfoil (*Myriophyllum spicatum*). To be planted here also are certain plants with both submerged and floating leaves, as a Pondweed (*Potamogeton americanus*).

Within the pond but not attached to the bottom are both submerged and floating plants, the former represented by a species of Duckweed (*Lemna trisulca*), Common Bladderwort (*Utricularia vulgaris*), and a Liverwort (*Riccia fluitans*). These are usually found near the surface, but seldom appear actually on it. Floating plants include some Duckweeds, as *Lemna minor* with single root, and *Spirodela polyrhiza* with many roots, likewise the Water Ferns (*Azolla caroliniana* and *Salvinia natans*). The Water Hyacinth (*Eichornia crassipes*) of the Pickerel Weed Family and the Water Lettuce (*Pistia stratiotes*) of the Aroid Family, both common in the extreme southern U. S., are floating plants of considerable size, and will do well outdoors in summer, but must be brought into a greenhouse in fall; they will not survive schoolroom conditions.

At the edge of the pond, either in the shallow water, or in soil not often or at all inundated, can be grown the typical plants of swamps. These are the amphibious plants, being neither harmed by prolonged submergence or by the drying up of the pond, at least not for some time. Trees, best planted outside the pond, but in wet soil, include such forms as the coniferous Bald Cypress (*Taxodium distichum*), the Black Willow (*Salix nigra*), and the Aspen (*Populus tremuloides*). Shrubs are such forms as the Willows (*Salix spp.*), the Speckled Alder (*Alnus incana*), and the Buttonbush (*Cephalanthus occidentalis*). The very edge of the pond will be suitable for growing such as the Primrose Willows (*Jussiaea spp.*), and the Water Willow (*Decodon verticillatus*), both of which are willows in name only. They should spread out from the shore over the water. Other creeping herbs, confined, however, to the shore, are the Water Pennyworts (*Hydrocotyle americana* and *H. umbellata*), the Silverweed (*Potentilla Anserina*), and the Sea-side Crowfoot (*Ranunculus cymbalaria*). Erect herbs in shallow water are such as the Pickerel Weed (*Pontederia cordata*), Yellow Water Crowfoot (*Ranunculus delphinifolius*), Broad-leaved Arrowhead (*Sagittaria latifolia*), the Mermaid Weed (*Proserpinaca palustris*), the Water Clover (*Marsilea quadrifolia*), and a Horsetail (*Equisetum fluviatile*), the last two related to the ferns.

Erect herbs outside the pond may include the Seedbox (*Ludvigia alternifolia*), Fireweed (*Epilobium angustifolium*), Reed Grass (*Phragmites communis*), a tall species very handsome in fruit, numerous sedges, and the Swamp Milkweed (*Asclepias incarnata*). Many ferns and related plants should do well here, as the three species of *Osmunda*, the Swamp Shield Fern (*Aspidium Thelypteris*), Sensitive Fern (*Onoclea sensibilis*), Chain Fern (*Woodwardia virginica*), Adder's-tongue Fern (*Ophioglossum vulgatum*), and a Little Club Moss (*Selaginella apus*). A Liverwort (*Marchantia polymorpha*) can be planted on damp ground, especially if a little charred wood be added.

Bog: A bog differs from a swamp in that there is little or no drainage, making the soil very acid. The vegetation of the two habitats is quite unlike. A bog will usually contain trees, often very close together, and considerable shade is thus afforded. Construction of an artificial bog is described in the catalogue of Gillett's Fern and Flower Farm. Excavation should be made to a depth of about three feet below the frost line. A lining can be made of clay or cement; if of cement it should be painted to prevent the lime contained therein from working into the soil, since lime is very detrimental to the acid requiring plants. An outlet about 8 or 9 inches from the surface should be made, and up to this point the excavation should be filled in with crushed rock or coarse gravel. One should, of course, avoid limestone rock. On top of this a layer of rich woodland soil should be placed.

Trees of the bog are few in species. One of the most characteristic is the coniferous American Larch or Tamarack (*Larix laricina*); this is a deciduous tree. An evergreen tree is found in another conifer, the Arbor Vitae (*Thuya occidentalis*). The Poison Sumac (*Rhus vernix*) is commonly found, but its poisonous nature does not recommend it, though some persons seem to be immune. Shrubs include such evergreen forms as the Common Cranberry (*Vaccinium macrocarpon*) and the Leather Leaf (*Chamaedaphne calyculata*), both members of the Heaths, while deciduous forms are represented by the Dwarf or Swamp Birch (*Betula pumila*) and the High or Swamp Blueberry (*Vaccinium corymbosum*). Many orchids are restricted to bogs or are at their best development therein; such are species of *Habenaria*, especially the Yellow-fringed Orchis (*H. ciliaris*) and the Purple-fringed Orchis (*H. psycodes*), the Small White Lady's Slipper (*Cypripedium candidum*), the Showy Lady's Slipper

(*C. hirsutum*), and the Stemless Lady's Slipper (*C. acaule*), the Snake-mouthed Pogonia (*Pogonia ophioglossoides*), the Grass Pink (*Calopogon pulchellus*), and the Bog Twayblade (*Liparis Loeselii*). All these orchids are easily grown. Insectivorous plants belong here, as species of Sundew (*Drosera*), of which the commonest perhaps are *D. rotundifolia* and *D. intermedia*, and the Pitcher Plant (*Sarracenia purpurea*). Some other bog herbs are the Buckbean (*Menyanthes trifoliata*), with foliage of three leaflets and fringed white flowers in early spring, the Lance-leaved Violet (*Viola lanceolata*), with elongated leaves and white flowers, and the Painted Trillium (*Trillium undulatum*) with white petals streaked with crimson. Of lower forms of plant life the Bog Moss (*Sphagnum spp.*) is so characteristic of bogs that it should always be included, and a species of Liverwort (*Conocephalus conicus*) occurs, though this is found also in dense woods.

Prairie: The prairie in the region about Chicago is the result of the drying up of swamp or bog; in the western states it is largely climatic in origin. The soil is neither highly acid or highly alkaline, and there is little shade except along streams. Trees and shrubs are likely to be absent except near water. Grasses form the most conspicuous vegetation, and these are available in many species. There are both tufted and creeping forms; the former are not so liable to become pernicious weeds. All those here mentioned are perennials. Tufted forms include Beard Grass (*Andropogon scoparius*), Panic Grass (*Panicum scribnerianum*), Vanilla Grass (*Hierochloë odorata*), a sweet-scented spring-flowering species, and Pallid Grass (*Koeleria cristata*), with pale spikelets in a spike-like inflorescence. Among creeping forms will be found the Cord or Slough Grass (*Spartina Michauxiana*), a tall coarse species best suited to the moister places in the prairie, Kentucky Blue Grass (*Poa pratensis*), and the Blue-joint Grass (*Agropyron Smithii*). Other herbs may have the foliage grass-like in appearance, or decidedly otherwise; both sorts seem to do equally well. Of those with grass-like leaves, some of them commonly called "Grasses," are the Cotton Grass (*Eriophorum viridi-carinatum*) a sedge with cottony fruit, Star-of-Bethlehem (*Ornithogalum umbellatum*), an introduced species escaped from old-fashioned gardens, of the Lily Family, Wild Orange-red Lily (*Lilium philadelphicum*), Star Grass (*Hypoxis hirsuta*), a small plant of the Amaryllis Family with yellow flowers, and the Blue-eyed Grass (*Sisyrin-*

chium spp.) of the Iris Family. Forms with leaves not at all grass-like include the Prairie Clover (*Petalostemum spp.*), Prairie Violet (*Viola pedatifida*), Painted Cup (*Castilleja spp.*) with colored bracts beneath the inflorescence, and many species of Composites, as the Compass Plant (*Silphium laciniatum*), Prairie Dock (*S. terebinthinaceum*), Cup Plant (*S. perfoliatum*), Common Yarrow (*Achillea Millefolium*) with finely cut leaves and white flowers, and the Ox-eye Daisy or Whiteweed (*Chrysanthemum leucanthemum pinnatifidum*), in appearance like a small single chrysanthemum, which in reality it is; this is often a very harmful weed in meadows, especially in the central states.

Plains: The plains are intermediate between prairie and desert. The plants grown here will need a soil neutral or somewhat alkaline, not too rich in humus, well drained, and a full sun and rather sparse watering, though care should be taken not to allow the soil to become too dry. In regions where the soil is rich, or where there is insufficient drainage, to secure plains conditions it is advisable to construct an artificial hill, one three feet high should be quite enough. The soil used should be largely sand. Grasses are still abundant, though they are of a more xerophytic type than those found in prairies. Some are native to the plains of the western U. S. Included among such are the Buffalo Grass (*Buchloë dactyloides*), one of the most valuable grasses for forage and soil conservation, and the Triple-awned Grass (*Aristida purpurea*). Other grasses, not restricted to the plains, but always occurring in dry soil, are the Porcupine Grass (*Stipa spartea*), a tall slender species with very long awns and extremely sharp callus, Sand Grass (*Triplasis purpurea*), a small species with wiry stems, and Wild Rye (*Elymus canadensis*), a tufted plant with thick spikes, the entire plant bearing a resemblance to the rye of cultivation. A fern, the Cliff Brake (*Pellaea atropurpurea*), is easily grown if limestone is provided. A few cacti will be found. Plains species of cacti include two small globular plants, *Mamilliaria vivipara* and *M. missouriensis*, while in open sterile soil from Nantucket to South Carolina near the coast will be found a species of Prickly Pear Cactus (*Opuntia vulgaris*), and in the middle west still another species, *O. rafinesquii;* this species also extends into the plains. Both species may very well be included. Small plants, whose lives are spent for the greater part of the year underground, are very characteristic here. The Sand Lily (*Leucocrinum montanum*),

resembling somewhat a white-flowered crocus, is a typical plains species, likewise certain onions as *Allium Helleri* and *A. mutabile*, both with conspicuous flowers and *Androstephium caeruleum* with light blue flowers, in form resembling daffodils. The yuccas, with long rigid evergreen leaves, should be represented, especially the Spanish Bayonet (*Yucca glauca*), occuring as far east as Iowa and Missouri. Many dwarf deciduous shrubs are found, as Western Indigo (*Amorpha fragrans*) of the pea family, with small pinnate leaves and spikes of brown-purple flowers, Dwarf Pea-Shrub (*Caragana aurantiaca*) with showy orange flowers and minute leaves, Three-leaved Sumac (*Rhus trilobata*) with scarlet fruit, and the Buffalo Berry (*Shepherdia argentea*) with silver-gray foliage and scarlet berries.

Desert: The environment of the desert does not differ much from that of the plains except that it is drier. As in the case of the plains some artificial construction may be needed. In well-drained situations it will be sufficient to excavate to a depth of two or three feet, and fill in with pure sand, otherwise it is advisable to build a sand hill; here again a height of three feet should be ample. As in the plains trees are absent except near water, though giant cacti and yuccas may be found, probably not growing in the east except under glass, and the Pinyon Pine (*Pinus edulis*), which is an inhabitant of very arid regions, and may be worth a trial. Some dwarf deciduous shrubs will be found, as the Desert Rose (*Rosa stellata*), covered with a felt of hairs, and the Sage (*Artemisia tridentata*), the latter very characteristic. The Silver Sage (*Artemisia frigida*), covered with silvery hairs, is a smaller species, and very easily grown; it has long been cultivated in eastern gardens. A peculiar gymnosperm, the Switch Plant (*Ephedra trifurca*), with the stems performing the work of photosynthesis, might be tried. The Edelweiss (*Leontopodium alpinum*) is a small woolly plant of the Alps, but is perfectly adapted to desert conditions. Like the Silver Sage it is not uncommon in gardens. Fleshy-stemmed plants are especially common in arid regions; all the cacti, so conspicuous in the desert, are of this type. They have many forms, as globular, barrel-like, leaf-like, etc. None of them, except the genus *Pereskia*, has functional leaves. The globular form is the most suited of all to the desert, since it has the greatest bulk with the least exposure of surface to evaporation. Fleshy leaved plants include the Century Plant (*Agave americana*), much cultivated, which will need the indoors in winter,

and the orpine family (*Crassulaceae*), especially in a genus *Sedum*. A plant of easiest culture is *Sedum acre*, a trailer with small leaves and yellow flowers; it is often found as an escape from cultivation in various parts of the U. S. The Hen-and-Chickens (*Echeveria secunda*) is a rosette plant with bluish leaves, producing many offsets, which remain close to the parent, whence the common name. An interesting plant for the desert group is the Bitter-root (*Lewisia rediviva*), state flower of Montana. It is a small deciduous plant, bearing a rosette of narrow leaves. It is closely related to the Spring Beauty (*Claytonia virginica*) of eastern and mid-western woods; the flowers, however, are much larger. The roots are so resistant to drying out that they can be shipped dry in the same manner as seeds. The desert contains also some bulbous plants, as the Sego Lily (*Calochortus Nuttallii*), state flower of Utah. It has long grass-like leaves and large, showy, somewhat tulip-like flowers.

Following is a list of dealers' catalogues, arranged in alphabetical order.

Gardens of the Blue Ridge, Ashford, McDowell County, North Carolina. Native deciduous and evergreen trees and shrubs, vines and trailing plants, native ferns, aquatic and bog plants, native lilies and other bulbous plants, native orchids, herbaceous perennials, leaf mold (*Rhododendron*) to provide acidity for growing certain plants.

Gillett's Fern & Flower Farm, Southwick, Massachusetts. Deals in about the same material as the preceding except that deciduous shrubs and trees and leaf mold are omitted. Describes the making of an artificial bog.

Naperville Nurseries, Naperville, Dupage County, Illinois. Deciduous and evergreen trees and shrubs, vines, perennial herbaceous plants.

Paramount Gardens, Plainfield, New Jersey. Mostly herbaceous perennials. Includes a few dwarf shrubs for the rock garden.

Rex D. Pearce, Merchantville, New Jersey. Rare seeds and bulbs. Very interesting and suggestive.

Carl Purdy, Ukiah, California. Herbaceous perennials, especially of the far west.

Rockmont Nursery, D. M. Andrews, Boulder, Colorado. Herbaceous perennials, deciduous and evergreen trees and shrubs, especially those native to Colorado.

Thompson & Morgan, London Road, Ipswich, England. Seed Catalogue. Has thousands of species from all parts of the world, adapted to all sorts of situations, many of them easily grown from seed.

William Tricker, Inc., Saddle River, New Jersey and Independence, Ohio. Aquatic plants for both deep and shallow water, bog plants. Describes how to make an artificial pond.

In conclusion I wish to thank Mr. Worrallo Whitney, Botany Editor, for certain valuable suggestions.

THE MEASUREMENT OF ACHIEVEMENT IN HIGH SCHOOL CHEMISTRY

By William C. Curtis

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[Editor's Note: Efforts to measure the results of teaching on the understanding and behavior levels deserve much encouragement from educators. The informational level has been overworked because it was an easy matter to devise tests of value on that level but relatively little has been accomplished on the two higher levels. The tests of the Committee on Tests and Measurements of the American Chemical Society have been excellent on the understanding level but they are for use with students of college age. This paper with its attempt to bring down to the high school age some of the wisdom of the objective test planners should engage the attention and support of high school teachers of chemistry. Frank B. Wade.]

In general improvements in tests and measurements have lagged behind the improvements in teaching methods, curriculum construction, and school supervision and administration. Despite its many defects and inaccuracies, the written examination is still the chief instrument of educational measurement.[1] A conscientious attempt should be made to increase the validity and reliability of this measuring rod. A valid and reliable test measures the one thing it purports to measure and measures it accurately. Such a test is characterized by objectivity of scoring and an adequate sampling of the material or abilities in question.[2]

In constructing a valid and reliable test of any kind, the capacities or abilities to be measured should be clearly defined. This can be readily accomplished in devising a test to measure a pupil's actual achievement in a high school subject. The examination should be designed to measure the *extent to which the specific objectives in particular* and *the ultimate goals of education in general* have been realized for each student examined.

To this end, the measurement of student achievement which has heretofore been largely confined to the informational level, should be extended to the understanding and behavior levels. The three levels of testing which conform to the modern philosophy of secondary education are as follows:—

I. *Informational Level:*—Tests constructed on this level are devised to measure the student's ability to memorize facts, statements, definitions, etc., from textbooks, lectures, and other sources. On this level no attempt is made to measure the students ability to *apply* this knowledge in new problem situations.

II. *Understanding Level:*—Tests constructed on this level measure the student's ability to apply the knowledge he has acquired to new problem situations. The new situations should differ from the original learning activities. Tests of this type should consist of items which cannot be answered by reproducing subject material memorized verbatim from a textbook, lecture, experiment, etc. This level embraces the informational level.

III. *Behavior Level:*—Tests constructed on this level are devised to measure capacities other than information and understanding. They are designed to measure the extent to which the students have acquired the desired general patterns of conduct as the outcome of their instruction in a particular subject or subjects.[3] It is extremely difficult to construct a valid and reliable test on this level. The problem here is to determine what a student should *know*, *feel*, and *do* when he has acquired the desired patterns of conduct as outcomes of certain learning activities. This level includes both the understanding and informational levels, and represents the highest level of testing. Testing on the first level should be limited to the measurement of basic skills and common essentials only. Tests constructed to measure the pupil's actual achievement in a particular subject should be confined largely to the understanding and behavior levels.

The purpose of this paper is to offer a few suggestions for constructing a valid and reliable test of a student's actual achievement in high school chemistry. In the light of the preceding considerations, the author feels that a satisfactory test of this kind would consist of questions involving the application of principles to new situations, the interpretation of experiments, and the functioning of the scientific attitude. A series of suggestive questions of these types is given below, along with suitable directions for answering them.

Suggestive Questions

Application of Principles

Directions:—Read each question and select the best answer. Then read the list of statements which give the reason for the answer to each particular question and select the correct reason for your answer. Record the number of the best reason on the line at the right of the best answer.

Problem:—Most drain pipe cleaners consist of concentrated sodium hydroxide (lye) which reacts with the grease to form a soluble soap. Several new preparations contain silicon or metallic aluminum besides lye.

a. These substances prevent the lye from decomposing..... ———

b. They make the cleansing action more effective..... 5
c. They serve as convenient fillers..... ____
d. They counteract the corrosive action of lye..... ____

Reasons:—

1. Some of the lye reacts with the aluminum or silicon, releasing hydrogen gas.
2. Silicon or metallic aluminum will not react with the lye in the dry state.
3. Negative catalysts are frequently added to substances likely to decompose on standing.
4. Inert fillers are often added to adulterate industrial products.
5. The escaping hydrogen mechanically agitates the solution and produces a froth.

Problem:—Cork for making linoleum is ground between revolving stones, to a very fine dust.

a. If the cork is supplied continuously to the revolving stones, an explosion may occur..... ____
b. If the cork is mixed with some suitable liquid and supplied to the revolving stones, a liquid linoleum is formed..... ____
c. If the cork is not supplied continuously to the revolving stones, an explosion may occur..... 3
d. Supplying the cork in small quantities will help to secure a fine powder..... ____

Reasons:—

1. Finely divided substances in the form of dust are highly explosive.
2. Combustible dust particles floating in air have a plentiful supply of air to enable them to burn rapidly.
3. Dust scattered through the air will explode if ignited or raised to its kindling temperature.
4. Finely powdered substances will not explode when floating in air unless they are ignited or raised to their kindling temperature.
5. When a solid is dissolved in a liquid, a liquid solution results.

Interpretation of Experiments

Directions:—In the first part of each of the following exercises you are given a description of an experiment and the results obtained. You are to assume that all of these facts are correct. The second part gives conclusions or interpretations of the experiment and its results. Some of these conclusions are sound and some unsound.

Read each exercise over carefully. Place the letter (N) in the blank space opposite each sound conclusion, and the letter (F) after every one that is unsound.

Experiment:—A sample of ordinary air was bubbled through lime water and then passed through a tower of anhydrous calcium chloride, a dehydrating agent. It was then passed over hot copper and subsequently hot magnesium which united with the nitrogen. The hot copper removed the oxygen forming copper oxide. An inert gaseous residue remained equal to about 1/200 of the original air.

Conclusions:—

1. This experiment shows that ordinary air is a mixture of gases which can be separated by mechanical means..... F
2. Nitrogen gas reacts chemically with hot magnesium forming magnesium nitride..... N
3. Carbon dioxide was removed from the sample of air by passing it through a solution of lime water..... N

4. Air contains a small fraction of an inactive substance or substances..... N
5. The air was first passed through the calcium chloride tower in order to remove the water vapor..... F
6. The remaining gaseous residue consisted of a part of the air which did not react chemically..... N

Experiment:—A patient was placed in a respiratory calorimeter to determine his respiratory quotient (the ratio by volume of the carbon dioxide exhaled to the oxygen inhaled). This quotient shows how and what kind of foods an organism is burning, and for a normal person it is about .85. For persons with diabetes it is usually greater than one. Before the determination was made, the patient had to be experiencing a minimum temperature change and at perfect rest with his alimentary canal empty. His respiratory quotient was .75.

Conclusions:—

1. For a normal person the volumes of oxygen inhaled and carbon dioxide exhaled are equal..... F
2. Most likely the patient did not have diabetes but there was something wrong with his metabolism..... N
3. The patient inhaled 100 volumes of oxygen for every 75 volumes of carbon dioxide exhaled..... N
4. Persons suffering from diabetes inhale more than 100 volumes of oxygen for every 100 volumes of carbon dioxide exhaled.. F
5. Certain conditions must be fulfilled before a patient's respiratory quotient can be determined..... N

Scientific Attitude

Directions:—The items of this section of the test are statements which can be classified under the headings A, B, C, D, and E shown below and at the top of each of the succeeding pages. Classify each pair of occurrences by checking the column which classifies it properly.

A. The first is practically the sole cause of the second.
B. The first contributes only slightly to the second.
C. The first is one of a number of the important causes of the second.
D. Both are results of the same general cause or causes.
E. The first bears no causal relationship to the second.

	A	B	C	D	E
1. In some cases the coloring matter of flowers is acid and some cases alkaline; some flowers are red and some blue.	X				
2. Oxygen was administered to a football team just before a game; the team played a great game.					X
3. The bodies of snails are moist; salt placed on their bodies kills them, their bodies dissolving.	X				
4. The barometer reading was high; there was a storm.			X		
5. A rumbling thunder storm; a pungent odor in the air.				X	
6. Tin cans are made of iron coated with tin; the interior of some tin cans turns black.	X				

A sufficient number of questions must be prepared to insure a thorough and representative sampling. In devising questions to measure the scientific attitude the assumption is made that a person who has acquired the scientific attitude or attitudes is

characterized by the freedom from dogma and superstition which usually results from a profound belief in the relation of cause and effect.[4]

After the test has been assembled its validity as a whole should be determined. In validating an informal objective test we are primarily interested in curricular validity, that is, the extent to which the test provides an adequate measure of the materials of instruction.[5]

The next step is to determine the validity of the individual test items. A convenient method of doing this is to administer the test to a representative group of students and divide the test papers into thirds, upper, middle, and lower, on a basis of the individual scores. All items which are too easy or too difficult and all items which fail to discriminate between the upper and lower thirds should be eliminated or revised.[6]

Finally, the reliability coefficient of the test should be determined. The reliability of the test may be determined by correlating the scores on the chance halves and stepping up the coefficient by the Spearman-Brown prophecy formula.[7] A reliability coefficient of .90 is generally considered acceptable.

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OLIVE OIL FOR AUTOS

By decree of the government of Tunisia engine lubrication must contain at least 25% olive oil.

A UNIT ON TRAFFIC SAFETY

By R. H. Gocker

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It is evident that something must be done about the steadily mounting automobile accident rate. Just what is to be done, and by whom, is a question. A few years ago when the accident rate in industry became appalling, it was found that safety campaigns were successful only when entered into by both employer and employee. Safety lectures and advice to employees were practically useless until they could see that the employer had done all he could to make the machinery and working conditions conducive to practicing safety habits. In other words, the campaign was a coöperative affair. Another parallel that might be drawn from the industrial campaign seems to indicate that the physical aspects should precede the mental. It seems that the attitude of the worker towards safety became a wholesome one only after the shop environment was as near accident proof as possible.

In a traffic safety campaign it seems there are three agencies that should coöperate. These three are the engineers who build our automobiles and highways, the law-making and enforcing bodies of the state, and the driver himself. In traffic safety, as in industrial safety, the physical aspects seem to take form first. Our automobile and highway engineers have already done much to prevent accidents. Our law-making and enforcing bodies have become more active and efficient, especially in certain communities where the accident problem has become most acute. The driver, however, has presented a problem that no one has done much about. This is an unfortunate situation since it has been discovered that the driver is the most potent part of the entire accident problem. Statistical studies show that from sixty to eighty per cent of all accidents could have been prevented by the driver.

There are several factors that seem to indicate that the school is the most logical agency to assume the responsibility of doing something in the way of education for the driver. First, there has been a rapid increase in the accident rate among drivers in the high-school and college age group. Second, no other institution is organized to contact so many people in a learning en-

vironment. Third, no other institution is equipped with the proper personnel for teaching. Fourth, education has for one of its aims the teaching and enjoying of good living. Good living, or perhaps living at all, is impossible today without making the proper adjustment to the traffic problem either as a driver or as a pedestrian.

A few schools already have rather well-defined programs of safety instruction. The elementary schools have done a very fruitful piece of work in teaching traffic safety from the pedestrian's point of view. A rapidly increasing number of high schools and colleges are giving some attention to teaching safety from the driver's point of view. A few high schools have launched out upon the unexplored field of teaching actual driving. In the Oak Park and River Forest Township High School at least one week (seven school periods) is given over to instruction in safety. The unit in safety is made part of the course in General Science. It was thought that it should be part of one of the required courses so that every pupil would get it. General Science seemed to be the course into which safety instruction most logically falls.

The proper operation of an automobile depends upon at least three factors: mental attitude, physical fitness, and skill. Since our course at the present time is of the class-room or academic variety, we are concerned mostly with developing proper mental attitudes toward the driving problem. Of the three factors, the mental attitude is probably the most important since it is virtually a pre-requisite to the development of physical fitness and skill. Questionnaire studies and conferences with parents and pupils seem to indicate that we have had some success in convincing the prospective driver that the automobile is a powerful, complex machine; that its operation is a complicated procedure, and that mistakes often lead to serious consequences. We feel however that our safety program is incomplete until we can combine with our academic course some practical instruction in actual driving. The content material as outlined below changes from semester to semester as new things to teach and better ways to teach them come to light.

TRAFFIC SAFETY

I. *Engineering*
  A. Highway engineering
    1. History of roads
      a. King's highway

b. Private toll roads and bridges
c. Public roads paid for by taxation (gasoline tax, license fees, etc.)

2. Development of paved roads
   a. Original purpose of paving was to keep vehicle out of the mud
   b. In the last three or four years highway engineers have become interested in safety
3. Safety features built into highways
   a. Banking curves. Amount of banking needed depends upon speed of vehicle. Route #6 through Missouri had curves banked for high speed. In the winter on ice, the slowly moving cars all slid down to inside edge of pavement. Banking must be moderate so a wide range of speeds may be accomodated
   b. Partially straightening curves
   c. Building guard rails on curves and hills
   d. Lighting center guide line with reflector buttons
   e. Planting bushes on shoulder of curves to cushion crashes
   f. Building wider shoulders
   g. Building gutters where necessary to prevent the formation of dangerous ruts beside the pavement
   h. Building viaducts
      1) Railroad grade separations
      2) Pedestrian's tunnels
      3) Highway grade separations
   i. Clover-leaf intersections (to eliminate all left turns at intersections)
   j. Elevated highways (proposed in Chicago)
   k. Multiple lane highways
      1) Three lane highways unsatisfactory
      2) Four lane highway not as safe as engineers had anticipated
      3) Divided lane highways seem to be safest. Germany and Italy have six lane divided lane highways with bushy evergreens growing in the center to eliminate cross glare of lights and to cushion crashes
   l. More guarded railroad crossings
   m. Lighting highways, especially hazardous places
4. Increased use of signs
   a. To accommodate strange drivers
      1) Dangerous intersections
      2) Change in top surface of pavement
      3) Change in width of road
      4) Curve
      5) Soft shoulders
      6) Dip in pavement
      7) Steep hill
   b. To relieve congestion (stop and go signs)
   c. To advertise regulations
      1) Parking limits
      2) Quiet zones
      3) School zones
   d. Danger of overdoing use of signs
   e. Necessity for uniformity

B. Automobile engineering

1. Car is not automatic like the horse was; lacks instinct of self-preservation
2. Car has been constantly improved and made more efficient and safe
3. Safety features built into cars
   a. Four wheel brakes
   b. Safety glass
   c. Low center of gravity
   d. All steel bodies
   e. Improved tires
   f. Improved lighting
      1) Depressed beam headlights
      2) Fog lights
      3) Foot operated dimming switch
      4) Stop light
      5) Reflector glass in tail light
   g. Improved vision
      1) Windshield wipers
      2) Defrosting devices
      3) Sun visors
      4) Rear view mirrors
   h. Doors hinged at front
   i. Smooth rounded door handles
   j. Smooth rounded radiator ornaments
   k. Recessed control buttons on instrument panel
   l. Flexible spoke steering wheel
   m. Governors

II. *Enforcement*

1. Most effective single tool for reducing accidents in a short time. Can not stand alone long. Must go hand in hand with engineering, and education
2. Good enforcement consists in arrests followed by prosecution
3. Good enforcement is selective in time and place; that is, efforts of officers are concentrated at certain places at certain times of day
4. Enforcement index. A measurement of enforcement. Index is found by dividing number of convictions, by number of personal injury accidents. Most cities have an index of less than one; a few have an index of five and a very few (Evanston and Milwaukee) have an index of ten
5. Philosophy of law
   a. An agreement made for common use of something. Everyone owns part of the road but everyone must use everyone else's part, thus making regulations necessary
6. Types of laws
   a. Speed laws. (Unmistakable correlation between speed and number of accidents.) In some states, e.g., Indiana and Illinois the speed law is prima facie. The law says the speed must be reasonable for time, place and conditions. So-called speed limits are merely suggestions as to what the law would consider reasonable
   b. Reckless driving (a catch-all law)
   c. Signaling turns and stops
      1) Has indisputable value
      2) Has gone out of style with coming of closed cars
      3) Need for uniformity of signals

d. Right of way laws
   1) Keep to right
   2) Vehicle on right has right of way at an intersection where there are no stop and go lights. Too many people always take right of way but never give it
   3) Speeding vehicles forfeit right of way
   4) Emergency vehicles always have right of way

e. Laws regarding vehicular equipment
   1) Horn
   2) Windshield wiper
   3) Brakes of certain efficiency
   4) Two headlights
   5) Stop and tail lights
   6) Certain types of lights on buses and trucks

III. *Education*

A. The car
   1. The function of the engine
   2. The function of the clutch
   3. The function of the transmission
   4. The behavior of car on road
      a. Car without driver is 2 or 3 tons of material being moved along by burning a fuel that contains 17 times as much energy as dynamite taken pound for pound
      b. Stored energy in a moving body varies as the square of the speed. To stop car all of this energy must be used up
      c. A car in motion tends to keep moving in a straight line
      d. Speed can be measured in terms of distance the car would travel straight up into the air

Speed	Altitude	Stopping distance
15	7½ ft.	7½ ft.
30	30 ft.	30 ft.
60	120 ft.	120 ft.

      e. Brakes are devices designed to use up the energy of a moving car. Under ideal conditions—dry pavement and locked wheels—a car going 30 miles per hour should stop in 30 feet. This performance is considered 100%. On that basis cars average about 50%. In some states the legal limit is 44%
      f. Impact due to sudden stop from speed of 30 miles per hour seems to be deadline. Human body cannot stand impact greater than that

B. The driver
   1. Most potent aspect of accident situation
      a. 60 to 80% of accidents could have been prevented by driver
      b. Cars have been constantly improved and made more efficient while the human mechanism has remained the same as it was during the horse and buggy days
   2. Driving a car is a full time job
      a. A continuous flow of messages passes through the brain
      b. In sports there are periods of concentrated effort separated by periods of comparative relaxation
      c. When learning to drive, the messages going through the brain are all of the thinking type. This makes them slower and more inaccurate
      d. As more and more of the messages become automatic

(habits) the driver becomes safer provided they are habits of doing the right thing

e. Some messages going through the brain must necessarily be thinking ones. Examples are route numbers and unusual road conditions

f. Deceitful thing about bad habits is that they do not cause any trouble most of the time. When the right combination of circumstances occurs, however, a bad habit will cause trouble

g. New drivers today have very superficial training as compared with training in typewriting or in golf or some other sport. "Hunt and peck" drivers are disastrous

3. Physical conditions of driver

a Eyesight
   1) Acuity of vision
   2) Breadth of vision (tunnel vision)
   3) Color blindness
   4) Eyes don't track, causing one to see double. This condition brought on by fatigue or intoxication

b. Physical strength
   1) Too weak to wrench wheel or apply brakes hard enough
   2) Too strong, creates a feeling of immunity to accidents because of strength. Comparison of men and women taxi-drivers in New York. Women have 3 times as many accidents as men but those of the men are much worse

c. Hearing

d. Physically crippled

e. Nervous stability

f. Reaction time
   1) Much over-rated in importance because of publicity given it by various measuring devices
   2) Different kinds of reaction time
      a) Reflex—eye wink or knee jerk
      b) Simple-known response to an expected stimulus
      c) Complex—to choose between a number of known responses to a stimulus
      d) Discriminatory—acting in a new situation—thinking
   3) Most reaction measuring devices measure only the simple type when driving involves all four types

g. Variation in physical conditions
   1) Fatigue
   2) Intoxication
   3) Sickness
   4) Temperature
   5) Worry

h. Certain combinations of physical disabilities make hazardous drivers. For instance, a combination of "tunnel" vision and poor hearing

i. A knowledge of physical handicaps is important so they can be corrected or compensated for.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

NATURE EDUCATION IN SPRINGFIELD, MASSACHUSETTS

By William Gould Vinal, *Nature Specialist*
National Recreation Association

I. In the Beginning—1636

Harvard University; Providence, Rhode Island; and Springfield, Massachusetts are observing their 300th anniversaries. In the early spring of 1635, William Pynchon, an Oxford graduate, sought to establish a fur-trading post far up "ye Great River" "nearest the 'Great Lake,'" a location "most fitly suited for a beaver trade." On May 16, 1636 twelve settlers received allotments along what is now Main Street, Springfield. The green flood plains of the Connecticut Valley produced wheat, barley, and corn; the river was alive with salmon and shad; and the forests abounded with game and "hog-mast." In the distance, Mt. Tom and the Berkshires loomed out of the haze.

From the beginning, the settlers in Agawam were naturalists. From the alluvial soil they harvested grain, if such escaped frost killings, the wild pigeons, or the scourges of caterpillars, which were much, "like a black worm." On account of the "scarcity of tymber" due to the Indian custom of burning over their lands, the selling of timber out of the settlement was prohibited (1647). The houses were chinked with clay and thatched with course grasses. The "musketoes" made faces "swelled and scabby." The earth was "unquiet" (1638) which caused considerable foreboding and ailment. All occupations, whether hunting, fishing, bartering or agriculture, were directly dependent on nature and her moods. Scientific procedure had not been born. Omens and moon gardening prevailed.

II. A Period of Collecting and Identifying (1860–1900)

Two centuries were to pass before the "fun-of-nature-study" could rise out of the haze of Puritanism. The necessity of spending all daylight hours in securing food and raiment was characteristic of the farmer's philosophy.

Joel Asaph Allen (born 1838)[1] was the first Springfield lad to throw off the yoke of condemnation to anyone seeking the pleasure of nature study. Like other boys he only went to the winter

[1] *Autobiographical Notes of Joel Asaph Allen*, published by the American Museum of Natural History, 1916.

session of school as he was needed on the farm. He shot warblers and vireos before he knew that they had names. At the age of fifteen, Webster's opened a new world to him. He copied all the natural history definitions from the dictionary, he was so starved for something to do in nature. His farmer-father had little sympathy with such yearnings. His teacher-mother was more patient with him. He was acquainted with no one who knew scientific names. From 1859 to 1861 he had a small museum which contained insects, minerals, chemicals, and 100 species of birds.[2] The first nurturing of his nature instinct was at Wilbraham Academy where he had Professor Oliver Marcy who later became dean of the faculty at Northwestern University.

Allen was a student of Agassiz (1862–1871) during the trying times of the Civil War. His poor health was a severe handicap to his career. He wanted to specialize on birds, but was given corals. As was characteristic of Agassiz (1807–1873) the young student was given no book or hint of direction. He was told to learn to observe and was then asked daily "what have you seen?" He must have satisfied the "Great Teacher" as he continued at the Museum of Comparative Zoology until 1885, when he was made curator of the American Museum. He was a member of three Agassiz expeditions—Brazil (1865), East Florida (1868–1869), and Rocky Mountains (1871–1872). In Brazil he traveled by pack-mule and made river journey in a dugout—the latter being 50 feet long and 4 feet wide. While in the Rockies and on the Great Plains he depended on buffalo meat for subsistence and buffalo chips for fuel. It was at a time when buffalo skins sold for $2.00 each. Allen was to Springfield what Jeremiah Jenks was to Providence—a museum naturalist.

While curator of the American Museum of Natural History, Allen established ornithological events which were to become of national significance. Frank Chapman became his assistant (1888) and later was assigned the Curatorship of Ornithology (1907). Allen was the first president, and for the six following years of the American Ornithologists' Union (1883–1890). During his regime several important committees were established. The Migration and Geographical Committee led to the Bureau of Biological Survey; the A. O. U. Nomenclature Committee of which Allen was a member, resulted in the well-known A.O.U. standard check list; and from the Committee on Protection originated the Audubon societies. For 27 years he was editor of

[2] "Birds of Springfield, Mass." Proceedings of Essex Institute, Vol. IV, No. 2, July 1864.

the societies' publication, ***The Auk***. Indiana University, when David Starr Jordon was president, awarded him a Ph.D (1886). He was too embarrassed to teach or lecture in the presence of strangers.

If Joel Asaph Allen was the father of bird study in Springfield (The Allen Bird Club is named in his honor) ***Mrs. Maria L. Owen*** (1827–1915) was the mother of botany. She obtained her interest in flowers on her native heath of Nantucket Island. As early as 1876 she started a botany class which the following year led to a club. This club had a prominent part in bringing about the erection of the Museum of Natural History building on the grounds of the public library. Maria L. Owen was the first president of the Botany Club and remained honorary president until her death, at the age of 88. In 1884 she formed the Springfield Woman's Club. Her efforts were not local. She wrote for ***Rhodora***, the official publication of the Massachusetts Botanical Society and published a ***Flora of Nantucket***.

Mary Ann Booth (1843–1922) is another Springfield woman who, although she had a lecture entitled "Around the Doorstep," and found 17 parasites on a sick bumblebee from her own back yard, was important enough in micro-photography to be made a Fellow of the Royal Microscopical Society, received first honor at the New Orleans Exposition (1885) and a medal at the St. Louis Exposition (1904). During the World War she studied the "cootie" and before this had helped to fight bubonic plague. She made photo-micrographs of germ-bearing fleas from rats for stereopticon slides by which she brought this information before scientific societies. During years of chronic invalidism she photographed parasites under the microscope at night. Her father was Samuel Colton Booth, a mineralogist. His collection was given to the Museum of Natural History. Although Mary Ann Booth inherited her ability, it was a trip to the seashore which aroused her first interest in seaweeds which in turn led to microscopic technique. In the same way that an engine must have the right mixture of air and gas to get combustion, so must an individual have both intelligence and opportunity to achieve. Her affliction may also have helped her to greatness. The story of her life could well be added to the list of Springfield science heroes for the younger generation to read.

Robert Oliver Morris (1846–1925) should be listed as an ornithologist. Like Allen, from the beginning his favorite hobby

was birds; he traveled in the Rockies on horse back; and was an enthusiastic gardener and sportsman. He also wrote for *The Auk* and in 1901 published the *Birds of Springfield and Vicinity* at his own expense. He left his ornithological material to the Museum and his bird notes to Aaron C. Bogg of Holyoke who is collaborating for their publication with Samuel Eliot Jr., a teacher at Smith College. Morris' interests were not limited to birds. He had an aquarium and kept pets and offered prizes to school children for identifying trees. A public school bears his name.

Dr. George Dimmock (1852) naturalist and genealogist, graduated from Harvard in 1877. His bent was toward insects and his papers were mainly entomological. He was editor of *Psyche*, the organ of the Cambridge Entomological Club.

Perhaps there are others who should be mentioned as outstanding in the period of collecting and identifying. If so, space forbids. The lesson to be learned is that nature offers unlimited resources for the hobbyist. Each student, when given freedom of selection, works enthusiastically and to the limit of his time and ability. And so in schools. Thomas Edison's teacher was a non-conformist. When Thomas did not conform to her dictatorship she sent home a note that he was a dunce and she could do nothing with him. Today the theory in the elementary grades, although not always the practice, is to allow children to select their own fields of endeavor. Springfield has a rich offering whereby children may make that choice—if not in all schools—at least in the community.

III. Springfield's Naturalist-Educators (1900–1936)

In each of these natural history surveys credit should be given to the scores of people with whom I have held interviews, and to the reference librarians who have given assistance. I am also mindful that for every statement there should be listed a source. My excuse for not giving detailed sources is that the great accumulation of references would soon tax what is already too large a space-consuming enterprise. A more extended task is left to the college student who seeks credit. In the meantime, reminiscences and general data are put on record for the future student of nature study. Louisville, Kentucky, stands out as a city that not only has pride in the accomplished events of its citizens, but the public library has a "Louisville Room" in which are kept clippings of Louisville authors, artists, musicians,

etc. In other cities the librarians look surprised—sometimes offended—that any one should inquire about a person that is not dead. A year's experience impresses upon the writer that the present all too soon becomes a matter of history. It is easy to take for granted that events should not be recorded. The writer's excuse, if one is necessary, for presenting historical data relative to the progress of nature education, is not only that it should be available to all teachers of elementary science, but that they should have a broad picture of the long struggle by which progress is made. What is needed today is not so much the discovery of new truth as the application of the truths of nature leadership which we claim to believe. In every city, all the steps in the history of nature leadership, no matter how ancient, still exist.

It is also sometimes a question as to which city a person belongs. *Dr. Luther Halsey Gulick* (1865–1918) might be claimed by many communities. Born of missionary parents, he lived and won distinction in many lands. He used to regret that he was not born in Indian days and traveled in covered wagons. He took a summer camping trip in Yosemite (1880), studied at Oberlin (1880–1882, 1885), and taught at Sargent School for a short time (1886). He introduced and took charge of the Physical Education Department at Springfield College (1886) in which place the Gulicks were known as an "experimental family." He was a great friend of G. Stanley Hall. In 1914 he presented his personal collection of books on physical education to the college in Springfield showing that his heart was still there. A few years later he was buried in Springfield.

Whether Doctor Gulick belongs to Springfield or not is a debatable question. Such facts seem trite when compared with the many influences of this great personality. He was the first president of the Playground Association of America (1906–1910); he developed the play idea of physical education; with James Naismith he was a co-inventor of basketball; he made a survey and progressive recommendations for the Y. M. C. A. in Europe at the beginning of the World War; and in partnership with Mrs. Gulick carried on experimental work in their family and camp, out of which was born the Camp Fire Girls on March 17, 1912. In 1914 the organization was incorporated with Doctor Gulick as first president (1914–1918).

There may be those who are still waiting for proof that Luther Gulick and Charlotte were naturalists. To those who knew them

or who visited their camp there can be no doubt. The camp fire program itself nurtures the love of the outdoors. The writer first saw the Gulicks at a meeting of the National Association of the Directors of Girls Camps when presenting a plan for a Nature Lore School for Nature Counselors. In the audience was an alert, sandy-haired, man, with sparkling blue eyes. Beside him was Charlotte Gulick who was to be elected to the Committee to formulate the first Nature Lore School (June 22–29, 1920).

Later the writer learned that in camp they were "Timanous" (Guiding Spirit) and "Hiiteni" (Life More Abundant). "Hiiteni" explained that many thought that the rocks and ledges made a camp impossible. It took the Gulicks to discover the vistas of the lake, the fun of feeding chipmunks, a spot for a garden, and the possibility of a water system. In about 1910, Camp Wohelo was formed for girls. It was an outgrowth of the family camping at Gales Ferry and at Sebago Lake, South Casco, Maine. The word wohelo is coined from the objectives of *work*, *health*, and *love*. So many Wohelo's sprang up, it became necessary to designate this one as Sebago-Wohelo. The writer takes pride in the fact that one of his students May Reynolds ("Hippo," the big little girl) after 14 years as nature counselor is now a co-director in Little Wohelo.

Luther and Charlotte Gulick were nature-educators. Concomitant learnings had not been invented in their day or play, health, education, camping, and religion might have been emphasized as possible concomitants of nature experiences. Doctor Gulick may not have plotted a curve to coin a new test but he measured maternal affection by turning a hose on a setting hen. He may not have originated community centers, but he saw that school buildings belonged to all the people and should not be locked at 3 P.M. A family circle, an educational camp, and a freedom from denominational beliefs made it possible to present the Gulick Hygiene Series, the Camp Fire Girls, and many other progressive ideas. Luther Halsey Gulick and Charlotte Gulick were naturalists in the true sense and they were far ahead of their day. If Springfield can claim them there is another star in Springfield's nature crown.

William A. Baldwin (1856–1936) was another pioneer in Progressive Education who chose Springfield for a home. A farmer lad, a graduate of Oswego Normal (1884), and a student at Cornell inculcated early nature study ideals. He was elected

Principal of Hyannis Normal School (1897) and during his 27 years as its head he was able to put into practice the principles of Pestalozzi (1746–1826) and Froebel (1782–1852). His book *Industrial-Social Education* (Milton Bradley Co., 1903) was dedicated "To my father, who, though a physician, purchased land as his boys grew old enough to work, and taught them farming." In 1901 when he replaced manual training by garden work he spoke to his staff somewhat as follows: "As a teacher and as a superintendent of schools I have been much interested in the introduction of nature work of the right kind into the schools, and have seen the wonderful joy and inspiration .... We take the young child away from the fields and woods, where he longs to be, and put him into a box, which some of us have been trying to adorn and make into a gilded cage."

An illustration of his "Vacation School" in his book, shows children carrying home products from their own gardens in baskets made by themselves. The children used the profits from their school gardens to purchase materials to make hammocks. Baldwin's ideas for vacation schools simulated successful leadership in camp. As the attendance was voluntary, the work had to be interesting, cooperative, and outdoors as much as possible.

The "Hyannis Idea" is best expressed in Baldwin's latest book *From the Old to the New Education*. Doctor Henry Turner Bailey wrote the introduction to both of Baldwin's books and pays high tribute to his ideals. The latter publication should be more widely used as a standard book for progressive nature teachers. In his latter days, Baldwin taught at the Rhode Island College of Education.

William Barrie Kirkham (1882) educated at Yale, was professor of biology at Springfield College (1921–1930). When Kirkham started at Springfield biology was limited to a two-term requirement for secretarial men and a third term was given in histology for the physical students. Kirkham should be remembered as the one who conceived the idea of taking his classes afield although according to the college paper,[3] the field course in its infancy was "little more than a 'nature-minded' parade of freshmen up and down the banks of Massasoit headed by the conscientious professor who pointed out specimens of biological interest." From this beginning Kirkham worked out the Freshman Camp, which has the strategic and unique location of

[3] *Springfield Student*, April 11, 1930.

being only a mile from the College campus and can be reached by hiking or by canoe. The buildings are of Pueblo design and were planned by Ernest Thompson Seton. George B. Affleck, the Dean of the College, and first president of the Allen Bird Club, organized Camp Craft Courses for the 150 students attending the camp.

Another nature study genius of Springfield is *Thornton W. Burgess* who was born at Sandwich, Cape Cod, in 1874 and lived there until 1891. The father died when Thornton was a baby which limited the times that the boy could go fishing. Referring to wood folks he said: "I often wished in those days that I was one of them," Burgess came to Springfield as an office boy for the Phelps Publishing Company. His first book *Old Mother West Wind Stories* (1910) sold well. Burgess then said: "I've told my last animal story. I haven't got another one in me." His bed time stories (began in 1912), "originated from a desire to inculcate early in a certain laddie who calls me 'Dad' something of the love of nature and the little people of meadow and forest which was my birthright." When his son went to visit grandmother, Burgess sent him a daily story about Peter Rabbit and Jerry Muskrat. Now he has a daily story in 70 newspapers and they are a great success. His Bed Time Story Hour started over station WBZ in 1925. These stories are "made in Springfield" and the Green Meadows are in a suburb called Longmeadow. 500,000 copies of his books are sold in a year. There seems to be no end to these tales which interpret plain homely American nature study to children.

I used to resent having his animals wear overalls and beaver hats until I heard him speak to Providence Children on a Saturday. There was a full house and a 500 overflow. When Mr. Burgess would say "Who is that?" there would be an enthusiastic chorus "Sammy Jay" or "Johnny Chuck." These names were household words. One could not deny but that Burgess had lifted the stigma from nature study. Today he does not find it necessary to dress the animals up.

Thornton Burgess goes to "no end of trouble" to find the facts of the case. I have forgotten how many days he spent on learning the truth about otter slides. Recently one of his lady radio listeners in Connecticut discovered an unusually large foot print in the mud by the pasture bars. She made a plaster of Paris cast of the print and sent it to Burgess for identification. The largest known foot of the kind discovered is the cougar,

and this foot was much larger than that possessed by the cougar. What could it be? Burgess could not tell and referred the matter to Doctor Wigglesworth of the Boston Society of Natural History. Thornton W. Burgess is chock full of goodfellowship. This is but one story he told me at dinner.

His books are a fund of information and point out the truth about daily lives. The *Burgess Bird Book for Children* (1919), the *Animal Book* (1920) and the *Flower Book* (1923) are illustrated by the well-known artist-naturalist Louis Agassiz Fuertes. The *Sea Shore Book* (1929) is also alive with interest. All of his books abound with sentiments of conservation and humane education. When the little boy realized that the Muskrat provides for ventilation he was willing to have his window opened. Burgess morals always point at the animal instead of the reader. The result is just as effective and, of course, much more pleasant. As Burgess says: When "I have a friend, the ugliest fellow that I know, and his tongue is put in backwards, and when he wants a drink he absorbs it through his skin, and he sings with his mouth closed, and he is covered with warts and is green, I get them right away."

Thornton W. Burgess was awarded the Distinguished Service Medal of the Permanent Wild Life Protection Fund (1918) by the New York Zoological Society. As Dr. Wm. T. Hornaday said: "Any man who can find his way into the hearts of a million children is a genius. If he carries a message of truth he is a benefactor. Thornton W. Burgess is both."

Fannie A. Stebbins recently retired from the position of Supervisor of Nature Study in the Springfield Public Schools. A dinner given her by the principals and teachers, whom she served was a testimonial of the same love and esteem which had always welcomed her at the school threshold. *Dr. Thomas M. Balliet,* superintendent of Springfield Schools (1888–1904) wanted nature work of the kind that was being done by Miss Stebbins in the fourth and fifth grades and gave her free hand to teach nature study to the girls in the City Training School (about 1889). Miss Stebbins used A. C. Boyden's book for suggestions for the work. Wilbur S. Jackman, (1855–1907) was teaching in Quincy and when his book appeared (1891) Doctor Balliet put a copy on each teacher's desk. That the teachers in that day complained because the answers were not given in the book makes that particular excuse age-worn and with the galaxy of present-day aids it is useless.

Miss E. M. Reed, a school principal suggested that Miss Stebbins demonstrate nature study with the children and that the teachers in training be given similar experiences. Miss Reed was very intelligent and far-seeing and taught the young teachers to stand on their own feet. Many principals of the present day look back to her training with gratitude. The training girls were assigned work and received constructive criticism. Out of this experience a course of study began to crystallize. Westfield Normal was now doing better work and city training was given up. This enabled Miss Stebbins to devote her whole time to the schools and she was called Supervisor of Elementary Science.

Miss Sarah Braissil, who trained under A. C. Boyden at Bridgewater Normal School was possibly the first supervisor of elementary science in Massachusetts. She was appointed in Cambridge. Miss Braissil had a farm on the South Shore. She devoted half of her time to supervisory work and the rest of the time to experimenting and raising berries and small fruit. To better prepare herself Miss Stebbins visited Miss Braissil.

It was about this time that Clark University, under the fostering care of Stanley G. Hall and the inspiring leadership of Clifton E. Hodges,[4] was offering nature courses in the summer school. Among the classmates of Fannie Stebbins were Arthur C. Boyden, who was later to become Principal of Bridgewater Normal (1906–1933), and Frank Murdock, a Bridgewater graduate, who was to teach geography at Bridgewater and later become principal of the North Adams Normal School. Mr. Boyden's outstanding work in nature study is well-known and his exhibition at the St. Louis World Fair received a medal (1904). His *Nature Study by Months* was the first nature study book published in Massachusetts. Murdock was a strong supporter of nature study and was especially interested in the garden side of the work. He always attended the school garden meetings and insisted that the Normal School girls be taught gardening. When he became deaf he almost concluded to give grades in botany according to the students success with living plants. Of the many visiting lecturers who came to Bridgewater between the fall of 1899 and the spring of 1924, two stand out vividly in the mind of the writer: They were Henry Turner Bailey and Frank Murdock—both champions of the cause of nature study.

[4] C. F. Hodges' *Nature Study and Life*, was published in 1902.

Miss Stebbins recalls that Hodges had mosquito larvae clearing up a murky aquarium. This was previous to the time that mosquitoes were proven guilty of carrying malarial parasites. Fresh water mussels were used to clear another aquarium. Hodges also had a theory that instead of keeping people in traps (behind screens in houses) the flies should be trapped. He also carried on immense correspondence to prove that the last passenger pigeon had disappeared. He offered a large reward to anyone finding a live passenger pigeon and "chased around" to see if they had really been found. Hodges was experimenting in the Worcester Schools at the same time that Clarence Weed was doing notable work in Lowell. Fannie A. Stebbins was traveling with notable classmates but was fully equal to keeping pace with these illustrious leaders.

Through the cooperation of the City Forester, *L. Fletcher Prouty* and the District Forester, Dennis Garlarneau, Miss Stebbins was furnished an area at Forest Park where all 7th grades could plant seedlings (about 1925). Later the same opportunity was extended to Indian Orchard, to Van Horn Park, and to the City Home. Each succeeding class planted seedlings and transplanted the older seedlings. These trees, which are mostly evergreens, are now a source of supply for other parks and school grounds.

Miss Stebbins was tireless in her efforts to give the teachers help. She gave courses in mineralogy and took them on field trips to study the rock stories of the Connecticut Valley. In 1910 the Museum of Natural History published her *Insect Galls of Springfield, Massachusetts and Vicinity*, which has 32 plates that are a great help to the novice.

Out of this wealth of experience came the *Course of Study for the Elementary Grades* (1927). Miss Stebbins was General Chairman and the Curriculum Revision Committee included both the teaching staff, subject matter specialists, principals, and supervisors. This was previous to the much heralded 31st year book, but it clearly gives general aims and specific objectives with the teacher a "guide, counsellor and friend." Fannie A. Stebbins is the mother of school nature study in Springfield. Her steadfast humanness, the merry twinkle of her eyes, and her ever-readiness to lend a hand are still potent factors in the nature-craftsmanship of the community. It was because she had so much to give that she was elected to the staff of the Nature Guide School of Western Reserve University where

she had an enthusiastic class in the study of ferns and mosses.

This brings to a close the story of Springfield's outstanding naturalist-educators. They are as varied and as illustrious as the technical-naturalists. In many cases they are national leaders—not only Springfield, but the whole country are better because they came—they saw—and they conquered. It is a story that should be told and that should be repeated.

IV. The Rise and Fall of Natural History Societies (1860–1936)

Springfield Natural History Societies have usually formed around the personality of broad-minded leaders. Each was an attempt to meet the needs of the time. The evolution of nature study has been slow and tedious, yet a glance at each epoch shows strides in achievement. A review of nature education in Springfield would not be complete without considering the influence of these societies.

Perhaps the earliest societies were agricultural. The appearance of Darwin's *Origin of Species* was stimulating thinking along the Connecticut Valley. Governor John A. Andrew, the war governor of Massachusetts, in an address before the New England Agricultural Society, September 9, 1864, at Hampden Park, Springfield, said: "You may set the village sexton above . . . Silliman or Agassiz . . . but when you have declined the sceptre of knowledge, you have not made the Merrimac or the Connecticut navigable. . . . I think the world will keep a warm place for her (New England) while Vermont leads . . . in . . . sheep-breeding, while Alvan Clark makes a telescopic object glass, ... While the new Museum of Zoology at Cambridge exceeds in the variety and extent of many important classes of specimens, the more renowned museums of London and Paris."

Fortunately, the records of the various scientific organizations are on file in the library of the William Pynchon Memorial Building. They are rich in content and are in safe-keeping until such time as some scholar accepts an invitation to interpret their offerings.

The *Springfield Scientific Association* formed about August 1, 1866 and by January 1 had 156 members. Rev. W. N. Rice was chosen president August 10, 1866. At the meeting of August 14 he read a paper on "The Influence of Physical Science in Modern Philosophy" and J. A. Allen read a paper on "The Birds of Springfield and Vicinity." August 21, Rice presented

a paper on "The Six Days of Creation." On September 8, 1866 the members had an excursion to Mt. Nonotuck. At noon, according to the secretary "The geologists turned their attention to layers of biscuit interstratified with lamina of ham and tongue while botanists dissected fruit instead of flowers." The organization evidently enjoyed a ten year existence as the last recorded meeting was for February 1, 1876.

The *Springfield Science Association* formed February 11, 1881. The first meeting of March 12 was in the High School Buildings. D. A. Lyle, the president, gave a paper on "Natural and Artificial Divisions of Chronometry" and on June 9, 1886 Dr. C. T. Stockwell read a paper on "Embryological and Physical Suggestion of an Individual Immortality." It was due to such meetings—which were almost continuous, following the Civil War, that the lay folks of Springfield were enabled to keep abreast of scientific progress.

The *Springfield Zoological Club* was organized June 1897, with 23 members. In 1898 Professor Cornelia M. Clapp of Mt. Holyoke College talked about the Lateral Line of Fish, W. W. Colburn gave an address on Hawks and Owls, Mr. A. S. Hanna, Principal of Barrows School on Instinct and William Orr of the High School reviewed the life of Professor E. D. Cope. By the card-catalog lists of the club one learns that the first Colorado Potato Beetle was discovered in Springfield August 7, 1875, the first elm leaf beetle June 5, 1892, and the last wild turkey was killed on Mt. Tom, January 1843. It is interesting to note that for many years Laura I. Mattoon served the club as treasurer for she was with Mrs. Charlotte Gulick on the first Nature Lore School Committee and has been outstanding in presenting nature lore in her camp Kehonka on Lake Winnepeesaukee. The presidents were W. W. Colburn and P. H. Pitkin.

Springfield's Civic Center is a potent cultural centre. The Library Museums, and High Schools are in close proximity. They are controlled by a private corporation but are free to the public. A High School student can easily hie to the library to study natural science, or to the Museum of Natural History to study the Samuel Colton Booth collection of local minerals, the Roberts M. Wallace collection of local birds, the Lyman Andrews exhibit of local flora, the edible and poisonous mushrooms of Springfield attractively arranged, local maps, or the model of Springfield. Or perhaps he wishes to inspect the Indian

group where a figure is hewing a chunk of stone from a boulder taken from a North Wilbraham pasture. Some catastrophe must have overtaken the Indian as the bowl was never fashioned. Fragments of bowls and other implements found in the top soil of the Allyn M. Seaver farm help one to visualize the life of the Connecticut Valley Indian. Or perhaps the student is seeking the cross section of the elm which excited the admiration of Oliver Wendell Holmes in his *Autocrat of the Breakfast Table*, who said: "The queen of them all is that glorious tree near one of the churches in Springfield. Beautiful and stately she is beyond all praise."

The *Springfield Museum of Natural History* (1859) has been solidly built and has been a powerful influence since its formation. In 1881 it began cooperation with the public schools. John H. Pillsbury, science teacher in the High School was made curator. Lectures were given at the museum and the classes used the collection. The new building (1899) was erected at a cost of $30,000.

William Orr, science teacher and later principal of the High School and finally Deputy Commissioner of Education for the commonwealth said in *Popular Science Monthly* (May, 1903, p. 42) "Rambles are a delightful means of leading girls and boys to a knowledge of the treasures of nature in the hills and valleys near their homes."

Springfield has always been at the front in the inauguration of nature study opportunities. The old skating house at Stone House Lane, Forest Park was built of discarded paving blocks from Main Street in about 1906. It hadn't been in use for years. Here was just the place to start a Trailside Museum. In cooperation with the Municipal Park Department this branch Museum was opened to the public August 3, 1931, just a month after the opening of the Cleveland Trailside Museum at the North Chagrin Reservation and four years after the beginning of the work at Bear Mountain in the Palisades Park (1927).

In 1935, an educational worker, Clifford B. Moore, started work with class room teachers. The Catherine Howard Library of Science was established in memory of a Springfield teacher.

The classes in nature study include not only story hours and Museum methods, but modeling and photography. For the past seven seasons the Museum has cooperated with the Park Department not only with the Trailside Museum but with

nature trails and Saturday morning nature walks. Mrs. Grace P. Johnson, the Director, is to be congratulated upon her ever progressive program.

V. And So What?

Today there are some twenty-five organizations in greater Springfield which have to do with natural history. They range from outing clubs such as the Allen Bird Club and the Berkshire Chapter of the Appalachian Mountain Club to sporting organizations such as the Izaak Walton League and the East Long Meadow Rod and Gun Club. Since 1898 the Springfield Fish and Game Association, one of the oldest sporting clubs in the state, with nearly 500 members, has been liberating game in local covers and draining and stocking ponds. The Wilbraham State Game Farm and the Wild Life Institute at Tolland, a training school for game keepers, are some of the local shrines.

When the story of nature study in Springfield has been told it presents an imposing picture. Dorothea Clark, the present Supervisor of Elementary Science in the Public Schools, is carrying out Miss Stebbins' lead. The principals, over a long period of time, are stressing nature in their individual ways. Josephine C. Foster, Sumner Avenue School, has an arboretum of 40 kinds of trees. Fannie Bemis, Robert O. Morris School, has noon bird walks and bird feeding stations. Pearl S. Southmayd, Thomas Balliet School, has an indoor and outdoor nature trail. The school can boast of 6 acres of forest land. Miss Edith Sauer, Kensington Avenue School, has a tree nursery and school garden. The teachers keep a permanent record which is added to each year by photographs and records. Sara Chase, Washington School and a Bridgewater graduate, has printed nature and tree books which are notable publications. And so one might ramble on. L. Fletcher Prouty, the City Forester, over a long period of years has cooperated with schools and museums. The Park Department is outstandingly progressive.

The Eastern States Exposition (1916) in cooperation with the Hampden County Improvement League with 172 acres, and 20 buildings is a distinctive Springfield educational institution for the demonstration of young folks' work and the products of home, field, farm and orchard. Springfield could well be the Mecca for nature enthusiasts who are contemplating a well-rounded civic nature program. Springfield has built long and well.

BIOGRAPHY AND HISTORY IN SCIENCE TEACHING

By C. Harrison Dwight
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In these days of extreme and rather mediaeval nationalism, it would be well for teachers of science to emphasize to their classes the international spirit of true scientific investigation. The smoke of the World War had not yet cleared away before an agricultural conference met in one of the belligerent countries, welcoming as delegates some of the best minds in the warring nations. The writer has found that students are interested in learning something of the life and times of the men quoted in the elementary physics course as scientific discoverers and writers. History has an important place in the development of a scientific subject, not only for its cultural value, but for the perspective which it offers to the subject as a whole. It calls to mind the attitudes of the contemporaries of the great scientists towards the latters' discoveries. It indicates the going and coming of "fads" in public interest, and the state of the civilization of the time. History may be then divorced from a memorization of dates, battles, and kings—unless the latter paid attention to the advancement of science by founding learned societies or academies, granting pensions, or subsidizing research.

In the past few years some interesting books and articles have appeared regarding, for instance, the life and works of Pasteur, the Curies, Newton, Pascal, Boyle, Rumford, Michelson, Faraday, and Steinmetz. Professor Lenard, himself a distinguished investigator, has published his *Great Men of Science*. The first three volumes of *Source Books in the History of the Sciences*, embracing astronomy, mathematics, and physics, have already appeared, each work being composed partly of short biographical sketches, and partly of excerpts from original papers. The reading public at present rather favors biography. Of this tendency the teacher may take advantage, thereby linking his own science with the lives of its great men.

Has it ever occurred to you, as a science teacher, to try to jot down privately from memory the names of as many scientists as you can? Does such a list contain Laplace, Poincaré, Gay-Lussac, Carnot, Lavoisier, Fresnel, Ohm, Keplar, Bunsen, Gauss, Galileo, Volta, da Vinci, Bernoulli, Roemer, Al Hazen,

Henry, Rowland, Pupin, Franklin, Faraday, Rutherford, Thomson, Boyle, Bohr, Oersted, and Huygens? What a galaxy can be set up almost at random! The international galaxy of science! After having written down the names you can recall, next attempt to place after each name at least one fact or principle or equation for which the scientist was celebrated. Even though the student nowadays obtains from his textbook quite a number of biographical impressions—verbal and pictorial—he is apt to pass them by unless the teacher especially tries to make scientific worthies appear as interesting human beings.

To illustrate one of the ways in which the life and works of a scientist may be presented, we shall consider the following example.

Edme Mariotte (1620–1684). This celebrated French scientist lived during the brilliant reign of Louis XIV, and was one of the first members of the French Royal Academy of Science. Shortly after founding this society in 1666 the King ordered Mariotte to design a water system for the fountains of the Trianon—a task which resulted in much pleasure to sightseers, but did little or nothing to advance science. Independently of Robert Boyle, Mariotte discovered the relation between the pressure and volume of a mass of air at constant temperature; he calculated correctly the decrease of atmospheric pressure with altitude; he determined, almost by a "laboratory method," the actual circulation of water over the Earth; and, by observing carefully the rise of vapor from solid ground, and the sea, he developed a theory as to the formation of raindrops in clouds. Mariotte might be called the first meteorological physicist. His deductions were so carefully reasoned from observed data, that they stand today as essentially sound and valid.

(Other biographical sketches by the same author will appear in future issues of this journal—Ed.)

JAPANESE TELEVISION

$1,500,000 has been allotted by the Japan Broadcasting Corporation for television research during the coming year. A laboratory to house the experiments of Professor Takayanagi, television expert, will be completed next month. The Japanese is reported to be 90 per cent successful in his experiments to use a daylight television receiver instead of the present fluorescent-light type. Hope of the JBC is to give television broadcasts of the 1940 Olympic games.

HISTORICAL MATERIAL IN SECONDARY MATHEMATICS

By Charles Lester McKee

Perry Township Public Schools, Lamartine, Ohio

Dr. J. E. Schrek,[1] writing in regard to changes and trends in the teaching of mathematics in Holland, stated that there was a gradually awakening interest in the history of mathematics and that historical matter of various kinds "have come to be quite common." This thought suggested a possible field for investigation in the subject of secondary mathematics in our own land, namely a survey and study of historical material in secondary mathematics. To bring out more fully the meaning and purpose of this survey and study three questions were used. (1) What is the degree of consistency in the content and amount of historical material presented in secondary mathematics texts? (2) Just what is the value of historical material in secondary mathematics? (3) Do high school texts deal with this material in an adequate way?

To aid in the securing of data and to simplify the answering of the above questions, the problem of historical material was broken down into three parts. The first part consisted of a survey of several standard high school textbooks in beginning algebra, a similar number of plane geometries, and a few texts in general mathematics. In making this survey the amount of historical material, names of persons mentioned historically, and the number of pictures pertaining to history of mathematics were noted. The second part of the problem was to consider comments and advice regarding historical material found in methods books and periodicals that deal with the teaching of mathematics. The third part of the problem was to contact in writing a few leading educators who conduct classes in methods of teaching secondary mathematics, and find their opinion regarding the value of historical material in the field of high school mathematics. It was also planned to ascertain if they advise prospective teachers of secondary mathematics to use such material when they actually become teachers.

It was hoped that a summary of these data secured in the three related fields would yield generalizations that would be of value to teachers who wish to present high school mathe-

[1] Dr. J. E. Schrek. "Holland." *Fourth Yearbook, National Council of Teachers of Mathematics*, p. 59.

matics in a more interesting and effective way and also to future authors of texts.

HISTORICAL MATERIAL IN MATHEMATICS TEXTS

In making the survey of several standard high-school mathematics textbooks to note the amount, the organization, and the nature of the historical material presented, eighteen publications were used. Nine of these were beginning algebras, six were plane geometries, and three were general mathematics. An effort was made to secure recent publications. Of the eighteen used, only three were published before 1930.

A study of the material found in these texts revealed a very wide variation in the amount and kind of historical material presented in the different texts. In all the texts the most material, 19 pages, was found in a text on general mathematics. In the algebras 14 pages was the maximum. In the geometries 10 pages was the maximum, followed by a close second with 9 pages. From these high points in amount of material, the curve swings downward to zero for two algebras, to the mere mention of one person in one general mathematics text, and to a fraction of a page of material in the case of one geometry.

In one of the texts, a geometry, a maximum of 27 persons was mentioned. As a group, the geometry texts mentioned more persons, while the algebra group mentioned fewest. Seven was the median number of persons mentioned in the entire group.

Nine of the eighteen texts examined had one or more pictures of historical nature. The maximum number of pictures was seven in a general mathematics text. The other nine texts omitted pictures.

In those texts containing historical notes some presented the material in a separate chapter or supplement. In one case this chapter was at the end of the book. In other cases the materials were presented as incidental to the main subject matter, at various places in the text. Some publications used the material in an introductory way at the beginning of the book or chapters. Most publications presented the material as notes at pertinent places in the text in connection with topics being developed.

Of the sixteen texts that included historical material, eleven considered the material important enough to be indexed. The five texts that did not have indexed material devoted as much as four and five pages to historical material and mentioned as many as twelve men. It would seem that if the material was

important enough to be placed in a text, it was important enough to have been indexed.

Twenty-eight persons were mentioned two or more times in the eighteen texts. Only four persons, Archimedes, Descartes, Euclid, and Pythagoras, were mentioned in all three types of texts. Of these four, Pythagoras was mentioned in fourteen texts and Euclid in eleven. Ten of these twenty-eight persons were mentioned only three times. No person was mentioned in all the general mathematics texts. Pythagoras was the only person that found a place in each of the six geometries. No person was given a place in each of the nine algebras. Space was given to Pythagoras in six and to Newton and Euclid in five algebras.

In addition to the twenty-eight names discussed above, forty-nine other persons were mentioned once only, making a total of seventy-seven different names found in the study of the texts. Brief consideration of these forty-nine names revealed that twenty occured in algebras, nineteen others in geometries, and the remaining ten were found in general mathematics.

In addition to the historical items mentioned in the discussion thus far, a number of the texts outlined the development of certain phases of mathematics as dependent upon certain nationalities or peoples. In this connection the Egyptians, Greeks, Arabs, Hindus, and Babylonians, were mentioned.

Entering into many of the historical notes and discussions were found details pertaining to the origin and development of numerous mathematical concepts and topics. Topics thus mentioned were: law of the right triangle, symbols of operation, origin of the term "algebra," simple equations, quadratic equations, graphs, exponents, radical signs, pi (π), metric system, dividing a line in extreme and mean ratio, and quadrature of the circle. One algebra presented a bibliography of the history of mathematics for the guidance of the student.

It was interesting to note the stress one author of high school texts placed upon a certain historical phase or individual, while another failed to mention the same. It appeared that the spectacular was often given at the expense of more important ideas, or that the personal element of the author was shown.

It was obvious with two of the authors failing to present any historical material and another presenting as much as nineteen pages, that there was but little agreement. This lack of agreement was further emphasized by the fact that in the sixteen

texts having historical material, seventy-seven men were mentioned, and almost sixty-five per cent of these were mentioned only once. Somewhat of a central tendency was revealed by the fact that two individuals were mentioned fourteen and eleven times respectively, and in all three types of texts.

These variations in practice suggested several questions: Just how many of the seventy-seven names are of sufficient importance to justify their inclusion in a high school text? What historical aspects of mathematics are really pertinent to the high school level? These questions were left unanswered. They portrayed the need for the establishment of criteria to be used as a basis of selection of names and topics. Well-planned class room experiments with a variety of material in different situations should serve to set up such criteria.

Since fifty per cent of the texts studied mentioned seven or more historical personages, this indicated in a general way that historical notes have potential value and should be given a place in teaching. The efforts by the authors in this direction were not consistent. The group as a whole showed no definite goal or purpose to be attained by the use of the notes placed in the texts.

COMMENTS AND ADVICE IN METHODS BOOKS

The second phase of the problem was to consider comments and advice regarding historical material found in methods books and periodicals that deal with the teaching of mathematics.

The methods books selected for this study were ones included in the bibliography of the *Ohio Curriculum Guides, Mathematics, Grades Nine and Ten* as well as any additional books that were available. The yearbooks of the National Council of Mathematics Teachers and the periodicals, SCHOOL SCIENCE AND MATHEMATICS and *The Mathematics Teacher* were also used.

Considering the great amount of material examined in this part of the study, only a comparatively scanty amount of pertinent material was found. Several of these volumes made no comment whatsoever.

Along this line, Blackhurst made an outstanding statement:

> Teachers are advised to make themselves reasonably acquainted with leading events in the history of mathematics, and thus to know that mathematics has developed in answer to human need, intellectual, as well as technical. They should use this material incidentally throughout their courses, for the purpose of adding to the interest of the pupils by means of informal talks.[2]

[2] Herbert J. Blackhurst. *Principles and Methods of Junior High School Mathematics*, p. 73.

With equal emphasis Hassler and Smith commented as follows:

> With . . . glimpses into the history of numbers the student will gain an appreciation of the fact that the processes of our number system were not handed down to us from a mountain of inspiration, but are the fruits of laborious thinking in the long and tedious journey from barbarism to civilization, and were developed as necessity demanded them. He should be made to see what a heritage is his.[3]

To quote Breslich:

> Historical and biographical notes appeal strongly to certain pupils and add to the interest of all. Writers of textbooks have long ago recognized this. Some insert the historical material in the form of footnotes, others present it in the body of the text. . . . It is decidedly worth while to let pupils see how closely the development of civilization is linked to that of mathematics.[4]

Lietzmann of Germany advised that the trend of mathematics in his country is to include the stressing of cultural values, implying greater attention to historical development. He states that:

> The mere citation of names and dates is not sufficient, but the history of a problem is investigated and traced to its source wherever possible.[5]

In contrast with these comments L. E. Mensenkamp[6] in a chapter, "Some Desirable Characteristics in a Modern Plane Geometry Text," does not mention historical material.

Browe advised that the mathematics teacher should use anecdotes from the history of mathematics. He presented this as one means to attain worth-while and lasting goals in the classroom and prevent the pupil going from class "with the remembrance of mathematics as 'Work so many problems on page so and so.' "[7]

Cook,[8] in writing of interest in mathematics and creating a mathematics atmosphere, called our attention to a mural painting portraying history of mathematics on the walls of Lincoln School, New York City.

Olson[9] made extensive study as to the changing content of

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[3] Jasper O. Hassler and Rolland R. Smith. *The Teaching of Secondary Mathematics*, p. 219.

[4] Ernst R. Breslich. *The Teaching of Mathematics in Secondary Schools*, Vol. 1, p. 72–73.

[5] Dr. W. Lietzmann. "Germany," *Fourth Yearbook National Council of Teachers of Mathematics*, p. 46.

[6] L. E. Mensenkamp. *Fifth Yearbook National Council of Teachers of Mathematics*, pp. 199–203.

[7] E. T. Browe. "Human Elements in Mathematics," *The Mathematics Teacher*, Vol. 24, p. 103–109.

[8] Mary Ruth Cook. "Stimulating Interest in Mathematics and Creating a Mathematics Atmosphere," *The Mathematics Teacher*, Vol. 24, pp. 248–254.

[9] Ruth Olsen. "The Changing Content of Ninth Grade Mathematics Texts," *The Mathematics Teacher*, Vol. 27, pp. 307–314.

mathematics texts and reported that she found an increasing emphasis in ninth grade mathematics texts, regarding historical and biographical notes.

Through this data it was revealed by those who have discussed this particular phase of mathematics that there is value in historical material, and that it should be given a definite place in teaching. These authors have in no way indicated criteria for a basis of selection for historical names and topics. Very little was said concerning the organization and presentation of such material.

QUESTIONNAIRE AND REPLIES

Since the third part of the study was to contact educators who conduct classes in methods of teaching secondary mathematics and secure their opinion regarding the value and use of historical material in the field of high school mathematics, a questionnaire was devised. A brief questionnaire consisting of three subjective questions was used. This type of questionnaire was chosen since it would give a better opportunity for individuality to be expressed in the replies. Two of these questions were supplemented with comments the purpose of which was to indicate the general nature of the answers expected. These comments were in no way intended to suggest that a certain answer was desired.

The following is the questionnaire:

(1) What are the potentialities of historical materials in secondary mathematics?
(For example, historical material may serve to create interest or build up a background of understanding and appreciation.)

. . . . . .

(2) What suggestions would you make in regard to the organization and presentation of such historical material?
(For example, a unit of historical material might be included alongside the usual units, or historical notes might be included at places pertinent to certain topics.)

. . . . . .

(3) Should definite views pertaining to the use of historical materials be presented to prospective teachers of high school mathematics in their methods classes in college or university?

. . . . . .

The questionaire was mailed to educators in widely separated parts of the United States. The educators were chosen on the basis of probable interest in the question because of their position in the teacher training field or as authors of secondary

mathematics texts. Replies were surprisingly quick and satisfactory. Eighteen replies out of twenty-seven inquiries were received.

A study of the answers to question number one revealed a rather wide variety of responses, from the mere use of historical matter as supplementary reading to the possibility of dramatization of "the slow but marked advance of mathematics through the ages" to make the "subject live." One answer stated a doubt as to the value of historical material and expressed the idea that much of the material was "mere filler" or represented a "hobby of the author."

All but four of the replies indicated two or more possibilities for historical matter. Five ways in which it may serve were listed in one reply. In the tabulation of the replies, it was interesting to note that stress was most often placed upon such potential values as "developing appreciation," "better understanding," "arouse interest," and "create interest."

An analysis of the replies to question number two revealed that educators have given serious thought in regard to the organization and presentation of historical matter in secondary mathematics.

Three replies were definitely against the "unit" plan of presentation, while one favored it as useful in certain situations. Eleven out of seventeen would prefer to deal with historical material as notes at "pertinent" or "strategic places" in relation to related topics.

The composite answer to the last question portrayed very definite agreement in regard to presenting views pertaining to the use of historical materials to prospective teachers of high school mathematics. There was not a single negative reply, but an added emphasis on the "yes" that mathematics teachers should be trained to appreciate and use the history of mathematics in their classrooms.

CONCLUSION

In the beginning of this article certain pertinent questions were raised, which were left unanswered at the time. The questions were: (1) What is the degree of consistency in the content and amount of historical material presented in secondary mathematics texts? (2) Just what is the value of historical material in secondary mathematics? (3) Do high school texts deal with this material in an adequate way? As the study progressed other

questions arose. These questions have been stated in preceding paragraphs with no attempt to answer because of the widening scope of the investigation. The unanswered questions may serve as possible suggestions for further study, investigation, or experimentation.

As to question number one, the study revealed much divergence of opinion in the use and amount of historical material. Short historical items were often scattered through the textbooks, or in other cases grouped in a separate chapter or supplement. There was little consistency in the selection of the material.

The second question, as to the value of historical material, led to the consideration of data in all three parts of the problem: the analysis of the mathematics texts, the comments and advice in methods books and periodicals, and the replies to the questionnaire. This data showed an increasing realization of the potential value of historical material and that it should have a place in the classroom work. Emphasis has been placed upon ways of securing these values by the very positive answers to question number three in the questionnaire.

At the same time it was obvious from the comments gleaned from the methods books and periodicals, and the answers to question one of the questionnaire that somewhat different reactions are expected from the high school student to such historical material as is included in his text. The central tendency of reactions expected was in the field of "interest," "appreciation," and "understanding."

The analysis of textbooks and the composite answer to question number two of the questionnaire, made it obvious that many texts deal with historical material, if at all, in a very inadequate manner. In the light of data assembled a few of the texts have approached this phase of the content upon a sound basis. Some others have made the right approach but have failed to include enough material.

It appears that authors are not fully convinced of the value of historical material, or have not had several classroom teachers try their proposed material on classes and report reactions of pupils. Too often the material presented was not pertinent or related to the current topic, and had the semblance of being "simply dragged in."

The historical backgrounds of algebra and geometry are not incidental in the mathematics classroom. The logical approach

to the subject matter in secondary mathematics would no doubt exclude historical material. The psychological approach would include such items and make good use of them. To include the historical material would be a further step to integrate subject matter.

There is more to high school mathematics than algebraic technique needed for success in college mathematics, science, et cetera, or geometric form and geometric implication needed both for college mathematics and for adult reasoning. The abstractions of mathematics should be made real. Mathematics should indicate its own historical development with special emphasis on the more recent centuries and even the last hundred years.

Further aid for correlation and integration of subject matter could be secured from the history departments of our educational institutions. In general history, all too often, little or no recognition has been given to individuals who have made very worth-while contributions to mathematical science and directly to our civilization.

A connecting thought that was always in the background and that led through the analysis of textbooks, the methods books, the periodicals and the replies to the questionnaire, centered in the classroom teacher of high school mathematics. The "personal equation" of the teacher is significant. Herein lies the power to show mathematics "ever growing with ever-accelerating growth, significant in itself, and very happily useful in interpreting everywhere the universe of experience and ever serving man's daily needs."[10]

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MATHEMATICAL MAGIC

BY CECIL B. READ

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To the mathematician, the term "Magic" is a misnomer, for the behavior of figures follows certain definite laws; but to the less informed person, certain performances seem to savor of the "Black Art." Although many parlor tricks, as we sometimes call them, have a mathematical background the fact is not always recognized. This is particularly true of card tricks. However, many short stunts may be developed from a mathematical background which for their demonstration require no equipment or previous preparation. In most of those mentioned the computations are so simple that they may be carried out in the head; although the use of pencil and paper will reduce the chance of an error in computation spoiling the effect of the stunt.

One rather effective stunt is as follows: those present are requested to (1) Write down your age, (2) Double it, (3) Add five to the result, (4) Multiply by five, (5) Add the number of members of your family. Now ask some individual to give you his result. Mentally subtract 25; the last figure of the result of your subtraction will be the size of the family; the first two digits will be the age. Before trying this stunt, it is well to convince yourself that it really works. Only one caution is needed, the rule fails for a family of over nine members.

(*More Mathematical Magic will follow in the June issue*—ED.)

Superintendent Varney of Stoneham, Massachusetts, announced on January 4, that the Stoneham junior and senior high schools had ceased the two-platoon system of attendance which has been in practice during the past few years. Return to the one-session plan was effected by adopting the recommendations of the Survey Committee which studied the Stoneham schools, grades VII–XII, during the summer of 1936.

Dr. Frederick J. Gillis, Assistant Superintendent of the Boston public schools, was chairman of the Survey Committee, Dr. Gillis personally appeared before the Stoneham town meeting in September, and, as a result of his presentation of the school situation, the town meeting overwhelmingly voted the appropriation necessary to carry his recommendation into effect.

THE APPLICATION OF CONTINUED FRACTIONS TO THE DETERMINATION OF EMPIRICAL CHEMICAL FORMULAS

By Arthur Porges
Chicago, Illinois

In the familiar elementary chemistry problem of determining the empirical formula of a compound from its percentage composition, the student is usually confronted only with atomic ratios which are those of small integers. For instance, in finding the simplest formula of a compound having the following composition by weight

Magnesium.....	26.28%
Silicon.....	20.39
Hydrogen.....	1.45
Oxygen.....	51.87

each percentage is divided by the atomic weight of the constituent, giving the number of gram-atomic weights of each element per hundred grams of compound. Thus,

$$\begin{aligned} 26.28/24.32 &= 1.081 \\ 20.39/28.3 &= .720 \\ 1.45/1.008 &= 1.444 \\ 51.87/16 &= 3.242 \end{aligned}$$

Dividing each of the above values by the smallest, .720, we obtain the atomic ratios

$$\begin{aligned} \text{Magnesium} &= 1.5 \\ \text{Silicon} &= 1.0 \\ \text{Hydrogen} &= 2.0 \\ \text{Oxygen} &= 4.5 \end{aligned}$$

It is apparent, in this example, that multiplying all the atomic ratios by two will reduce them to the integer ratios

$$\begin{aligned} \text{Magnesium} &= 3 \\ \text{Silicon} &= 2 \\ \text{Hydrogen} &= 4 \\ \text{Oxygen} &= 9 \end{aligned}$$

thus giving as the simplest formula for the compound

$$Mg_3Si_2H_4O_9.$$

We must have recourse to a better method than mere inspection, however, when we are dealing with a formula like $Mo_{24}O_{37}$. The percentage composition of this compound is

$$\begin{aligned} \text{Molybdenum} &= 79.558\% \\ \text{Oxygen} &= 20.441 \end{aligned}$$

Upon proceeding as in the first example, we obtain the ratio O:Mo = 1.5416. Since we cannot find by inspection the two smallest integers whose quotient is 1.5416, it is necessary to find fractional equivalents by means of continued fractions. Expressing 1.5416 as a continued fraction, we obtain

$$1.5416 = 1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{5+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{25+\cfrac{1}{2}}}}}}}$$

The convergents of the fraction are 1, 2, 3/2, 17/11, 20/13, 37/24, 945/613, and 15416/10000. The first three and the last of these approximations may obviously be dropped from consideration. Of the three remaining, division shows that 17/11 lacks the required accuracy; 37/24 checks perfectly and must be correct since it has the same accuracy as 945/613 relative to the original percentages and is the smaller of the two. Thus the required formula is found to be $Mo_{24}O_{37}$, a result impossible to obtain with the ordinary methods at the disposal of the student of theoretical chemistry.

A SCHOOL OF NATURAL SCIENCE FOR MID-WEST STUDENTS

This summer students of the Central States will have easy access to a school for the study of nature—plants, animals, stars, rocks—in a beautiful setting prepared by Nature especially for this purpose. See the announcement of the Lake Geneva School of Natural Science on page 621.

ROBOTS SELL SCIENCE

By Willard Geer
Reedley Joint Union High School and Junior College, Reedley, California

Robots made of steel and wire, untiring creatures of science, the promised slave and servant of the future, mechanical men—why not use them in a campaign to sell the science department to the community in which we are teaching?

If we can but take one of these creatures, student planned and student constructed, and put him to work for us we will bring to our side the accumulation of interest that the features in the Sunday Supplements and the Buck Rogers serials have been developing for the past few years. Believers in scientific prophecy and unbelievers alike will raise their eyebrows when told that the physics department up at school has a real live robot who can see and do things, yes—all by itself!

A major difficulty in advertising the work of any science department lies in the fact that even though the layman does come to visit the department and is impressed by the type of work that is being done, he has no vocabulary to recreate for others the feelings which he has experienced. The principles, the laws, the apparatus upon which the demonstrations depend are unknown to him, and the more spectacular pieces of apparatus are without names so far as he is concerned. What can he tell his friends after his visit to a science department exhibit? "They've got a good science class up at school," and lacking lucid details, the story gets no further, dying with the first attempt at being retold.

To solve this difficulty, we at Reedley follow a plan where the fundamentals are covered thoroughly, but not tediously, and checked upon by standardized tests, and followed by a period where the class is stimulated to use its own knowledge and ingenuity in the construction of vacuum tube amplifiers, public address systems, relays that work by approach and relays that work by light operated photoelectric cells, sound wave apparatus to enable students to see their own voices, radio receivers and transmitters, wind tunnels to test models of streamlined cars, high voltage apparatus built upon static and tesla principles, and many other lesser projects. However, local visitors could see all this and fail to see the modernity of this type of

work, were it not for the fact that at the "open house" exhibit, over there in the corner four boys are dressing up relays and making robots out of them. It is this that catches the eye of the visitor. He remarks, "So that is the way those mechanical men work, and to think that those boys are making real robots right here in our school!" "Won't Sam be surprised when I tell him that the kids are making a mechanical man that watches you come and when you get in front of the door he swings it open for you!" "Martha won't believe that either. That little red headed boy sure knew his stuff about those radio tubes and motors he had hooked up there in that mechanical man's chest!"

Thus the visitor is no longer inarticulate and is voicing his approval of a department which he begins to understand, and which he sees is giving the student contact with a science as alive to the student as the world it is remaking.

Our work along the lines of this plan have reaped a gratifying reward, not only from the fact that our school robot was invited to represent our more or less small school at the San Diego Exposition, was photographed by a large rotogravure syndicate, and brought requests for descriptions from several national education magazines and also several trade journals from apparatus companies, but of more significance to us, the success of our graduates in higher schools and in the scientific fields in which they have continued after their school days are over—this coupled with the atmosphere of confidence and cooperation which our patrons of the school district feel in our year's work. We base our whole endeavor upon the belief that the boy who can make a thing understands the principles upon which it works.

POLISH NATIONAL ALLIANCE

In June, 1937, Alliance College at Cambridge Springs, Pa. will celebrate the 25th Anniversary of its founding by the Polish National Alliance.

In 1912 William Howard Taft, then President of the United States, inaugurated the educational program which has as its aim the development of two cultures, Polish and American, and leadership for Americans of Polish extraction.

A cross-section survey of graduates reveals that 79% of the graduates have gone to universities; of these, 89% have received Bachelor's degrees or higher degrees, attending 57 different universities. Eighteen per cent have entered the legal profession, 13% the medical profession, 6% each to pharmacy and teaching. In all, 31 professions were represented. Two per cent were unemployed.

In connection with the 25th Anniversary a pageant is planned and a number of prominent speakers will appear. Educators are cordially invited to attend this program.

SHOOTING SURFACE FILM

By Haym Kruglak

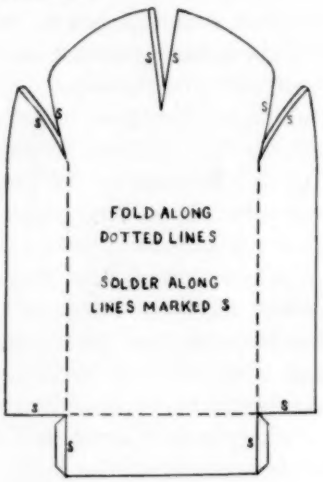
Sheboygan High School, Sheboygan, Wisconsin

The following demonstration has been received most enthusiastically by our physics pupils.

A small boat is constructed out of fine mesh copper screen. The boat is then placed in a large dish of water. The film formed in the mesh of the boat will support it.

A blank is fired from a pistol at a distance of about two feet from the boat. The concussion produced by the pistol shot is sufficient to overcome the surface tension of water. The surface film supporting the boat breaks, and the boat sinks.

The boat can be made out of 60 to 100 mesh copper screen. The following design is quite satisfactory.



½ ACTUAL SIZE

In our demonstration a .22 revolver was used. If a pistol can't be obtained, a firecracker will work equally well.

It goes without saying that the boat will not float unless it is *perfectly* dry.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or

proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1479, 80. *V. C. Bailey, Emory, Va.*

1484. *Proposed by Hugo Brandt, Chicago.*

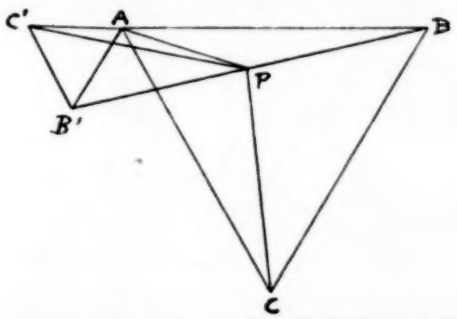
Given a point, P, to construct an equilateral triangle ABC, so that $PA=3$, $PB=4$, $PC=5$. Also calculate the length of AB.

Solution by D. F. Wallace, Minnesota.

Through P draw BB' making $PB=PB'=4$.

Draw PA, making angle $APB'=30°$.

Construct the equilateral triangles ABC and $AB'C'$ so that P shall lie inside ABC and on the side of AB' opposite C'. Then triangles ABC and $AB'C'$ each comply with the conditions of the problem.



PROOF: Because $\angle APB=150°$, if a circle be circumscribed about PAB its center will lie on the side of AB opposite C and AB will subtend an arc of 60°. Therefore AB is equal to the radius of this circle. Therefore, by the solution of problem 1458 (December 1936)

$$PA^2+PB^2=PC^2=25. \text{ Therefore } PC=\sqrt{25}=5.$$

The center of the circumcircle of triangle PAB' will lie on the side of AB' opposite C' and AB' will subtend an arc of 60°, since $\angle APB'=30°$. Therefore AB' is equal to the radius of this circle. Therefore, by problem **1458:**

$PA^2+PB'^2=PC'^2=25$. Therefore $PC'=\sqrt{25}=5$.

Calculation of the length of AB:

$$AB^2=PA^2+PB^2+2PA\times PB\cos 30^\circ=25+\frac{24\sqrt{3}}{2}=25+12\sqrt{3}.$$

$$=25+12\times 1.732051+=45.784612+$$

Therefore $AB=\sqrt{45.784612}=6.766$ approximately.

Calculation of the length of AB':

$$AB'^2=PA^2+PB'^2-2PA\times PB'\cos 30^\circ=25-\frac{24\sqrt{3}}{2}=25-12\sqrt{3}$$

$$=25-12\times 1.732051+=4.215388+$$

Therefore $AB'=\sqrt{4.215388}=2.053$ approximately.

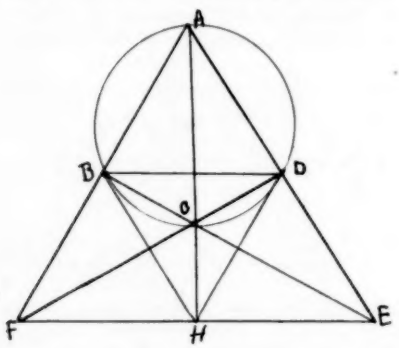
Another reference to this problem is **1264,** April, 1933.

Solutions were also offered by A. R. Haynes, Tacoma, Wash., Charles W. Trigg, Los Angeles, V. C. Bailey, Emory, Va., Hyams Washam, Sherman, Texas, Julius Freilich, Brooklyn, N. Y., Hyman Marcus, N. Y. C., W. E. Buker, Pittsburgh, Pa., and the proposer.

1485. *Proposed by H. R. Mutch, Glen Rock, Pa.*

Quadrilateral $ABCD$ is inscribed in a circle with $AC\perp BD$. AD and BC meet at E; AB and CD meet at F; tangents at B and D meet at H. Prove that AC and EF contain H.

Solution by D. F. Wallace, Minnesota.



This problem calls for proof that AC and EF pass through H. Since H is the intersection of tangents from B and D, AC can pass through H only in case AC is a diameter of the circle. Since BH and DH must be equal, H is in the perpendicular erected at the mid point of BD and can lie in no other perpendicular to BD. Therefore in case, and only in case, AC is a diameter does it pass through H. The following is proof that EF passes through H in case AC is a diameter.

Since AC is a diameter perpendicular to BD it bisects BD. Therefore $AB=AD$ and $\angle ADB=\angle ABD$.

$\angle FBH=\angle ADB$ since it is an angle between the tangent BH and the chord AB produced.

But $\angle ADB = \angle ABD = \angle ACD = \angle FCH$.

Therefore $\angle FBH = \angle FCH$.

Therefore a circle may be described about the quadrilateral $BCHF$.

FBC is a right angle being supplementary to an angle inscribed in a semicircle.

Therefore $\angle CHF$, being the angle opposite to the right angle FBC in the inscriptible quadrilateral $BCHF$ is a right angle.

In the same way it may be shown that $\angle CHE$ is a right angle.

Therefore $\angle CHF + \angle CHE$ is equal to two right angles. Therefore FHE is a straight line. Therefore EF passes through H.

EDITOR'S NOTE: Mr. Wallace gives proof that EF passes through H, if AC is not a diameter, and hence does not contain H. Hence if the condition that $AC \perp BD$ is omitted, the new problem is quite general.

A solution was also offered by Hyman Marcus.

1486. *Proposed by Isadore Chertoff, Bayonne, N. J.*

Prove $\log_b a \cdot \log_c b \cdot \log_d c \cdot \log_e d \cdots \log_n m \cdot \log_a n = 1$.

Solution by David Rappaport, Chicago, Ill.

Change each log except the last one to the base a by using the formula,

$$\log_a x = \frac{\log_b x}{\log_b a}.$$

The product becomes,

$$\frac{\log_a a}{\log_a b} \cdot \frac{\log_a b}{\log_a c} \cdot \frac{\log_a c}{\log_a d} \cdot \frac{\log_a d}{\log_a e} \cdots \frac{\log_a m}{\log_a n} \cdot \log_a n = 1$$

Since the denominator of each fraction is the same as the numerator of the next fraction, all terms are cancelled except the first one, and we get

$$\log_a a = 1, \text{ which is true.}$$

Solutions were also offered by Charles W. Trigg, Los Angeles, J. E. Dinger, Kohoka, Mo., J. Slavin, Brooklyn, N. Y., H. R. Mutch, Glen Rock, Pa., John F. Babcock, Los Angeles, A. R. Haynes, Seymour Sherman, Ithaca, N. Y., Marques Wallace, Mexico, Missouri, Edwin W. Bailey, Delta, Pa., Hyman Marcus, Julius Freilich, Brooklyn, N. Y., and the proposer.

1487. *Proposed by David Rappaport, Chicago.*

A circle is inscribed in a square whose side is a. Find the radius of the small circle inscribed in the corner of the square tangent to the two sides of the square and the given circle.

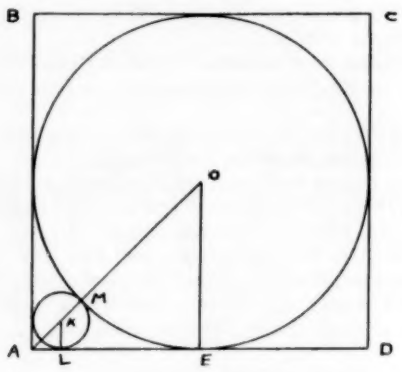
Solution by John F. Babcock, Cumnock College, Los Angeles.

In the figure the side OA of the square is a, and KL, the radius of the small circle, r. Drop perpendiculars OE and KL to AD. Triangles AEO and AKL are right isosceles triangles and since the ratio of 1, 1, $\sqrt{2}$ exists between the sides then,

$$AO = \frac{a}{2}\sqrt{2}, \quad AK = r\sqrt{2}, \; AK + KM + MO = AO$$

By substitution

$$r\sqrt{2} + r + \frac{a}{2} = \frac{a}{2}\sqrt{2}$$



$$r(\sqrt{2}+1)=\frac{a}{2}\sqrt{2}-\frac{a}{2}.$$

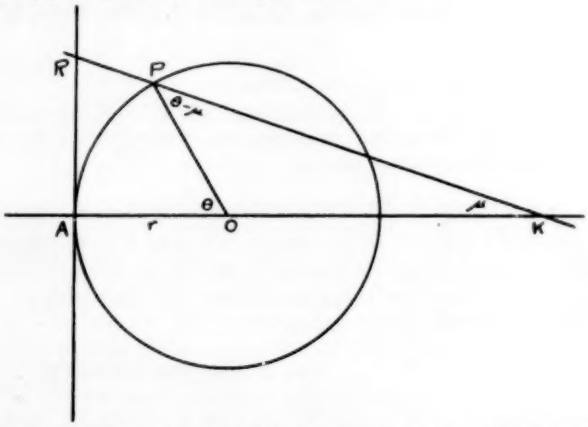
Solving for r

$$r=\frac{a}{2}\left(\frac{\sqrt{2}-1}{\sqrt{2}+1}\right)=\frac{a}{2}(3-2\sqrt{2})=0.086a.$$

Solutions were also offered by Edward C. Varumm, Clyde, Ohio, W. R. Smith, Chicago, A. R. Haynes, W. E. Buker, Pittsburgh, Pa., J. Slavin, Brooklyn, H. R. Mutch, H. M. Zerbe, Wilkes-Barre, Pa., Edwin W. Bailey, Delta, Pa., Hyman Marcus, New York City, Julius Freilich, Brooklyn, N. Y., and Charles W. Trigg, Los Angeles, Pascal Poe, Jr., Gunnison, Colorado, Milton Brooks, Philadelphia, Pa., D. F. Wallace, and the proposer.

1488. *Proposed by G. W. Ames, Milan, Mo.*

Two perpendicular lines meet at A. A fixed circle with center, O, is tangent to one of the perpendiculars at A. If a secant of this circle meets OA at K, the circle at P and the other line at R, and if arc $AP=AR$, find the limiting position of K as P approaches A.



Solution by Charles W. Trigg, Cumnock College, Los Angeles.

Let $\angle AOP=\theta$, $\angle AKP=\mu$, $AK=m$ and $AO=r$. Then $AR=AP=r\theta$

and $\angle OPK=\theta-\mu$, $OK=m-r$. In $\triangle RAK$,

$$\frac{r\theta}{m}=\tan\mu. \tag{1}$$

In $\triangle POK$

$$\frac{\sin\mu}{r}=\frac{\sin(\theta-\mu)}{m-r}=\frac{\sin\theta\cos\mu-\cos\theta\sin\mu}{m-r}.$$

Hence

$$\tan\mu=\frac{\sin\mu}{\cos\mu}=\frac{r\sin\theta}{m-r+r\cos\theta}. \tag{2}$$

Equating values from (1) and (2) and solving,

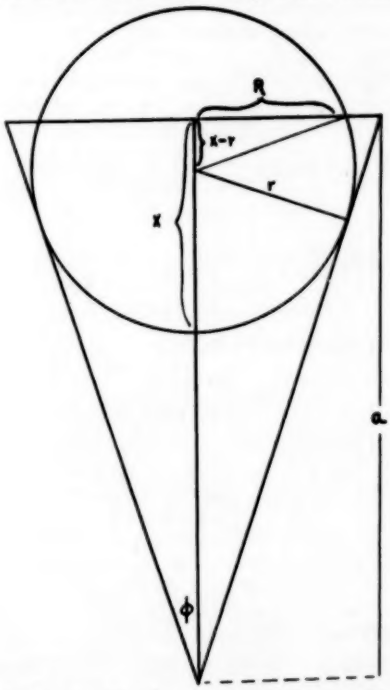
$$m=\frac{r\theta(1-\cos\theta)}{\theta-\sin\theta}=\frac{r\theta\{1-[1-(\theta^2/2!)+\theta^4\cdot f(\theta)]\}}{\theta-[\theta-(\theta^3/3!)+\theta^5\cdot F(\theta)]}=\frac{r[\frac{1}{2}-\theta^2\cdot f(\theta)]}{\frac{1}{6}-\theta^2\cdot F(\theta)}.$$

Now proceeding to the limit, $\lim_{\theta\to 0}m=3r$. So the limiting position of K as P approaches A is a point on AO such that $AK=3AO$.

A similar solution was also offered by Hyman Marcus, New York City.

1489. *Proposed by L. S. Gray, Tacoma, Wash.*

An invented right circular cone has an altitude of 16. The generating angle is 30°. Find the radius of the sphere, which, when carefully dropped into the cone full of water will cause the greatest overflow.



Solution by Charles Koren, Bayonne, N. J.

Since the general case is of interest, we will first solve that case, and

then evaluate the given date by substitution.

Let a represent the altitude of cone,
ϕ the generating angle
r the radius of the sphere
R the radius of base of spherical segment
x the altitude of the spherical segment of one base submerged in the cone.

The volume of a spherical segment of one base, using our letters is

$$V=\tfrac{1}{2}\pi R^2x+\tfrac{1}{6}\pi x^3=y \text{ (the function to be a maximum).} \tag{1}$$

From the small triangle we can solve for R in terms of r and x.

$$R^2=2rx-x^2.$$

Substituting in the function y we have

$$y=\tfrac{1}{2}\pi(2rx-x^2)x+\tfrac{1}{6}\pi x^3. \tag{2}$$

Now

$$\sin\phi=\frac{r}{r+a-x} \text{ or } r=\frac{(a-x)\sin\phi}{1-\sin\phi}. \tag{3}$$

Substituting this value of r in (2) we get

$$y=\tfrac{1}{2}\pi\left[\frac{2(a-x)\sin\phi}{1-\sin\phi}x^2-\tfrac{2}{3}x^3\right],$$

which is the function to be made a maximum by varying x. Differentiating with respect to x, and equating to zero,

$$\frac{dy}{dx}=\tfrac{1}{2}\pi\left[\frac{2\sin\phi}{1-\sin\phi}(2ax-3x^2)-2x^2\right]=0.$$

Hence

$$\frac{2\sin\phi}{1-\sin\phi}(2a-3x)-2x=0$$

and

$$\frac{4a\sin\phi}{1-\sin\phi}=x\left(\frac{6\sin\phi}{1-\sin\phi}+2\right).$$

Solving for x in above equation we have

$$x=\frac{2a\sin\phi}{2\sin\phi+1}. \tag{4}$$

Therefore

$$a-x=a-\frac{2a\sin\phi}{2\sin\phi+1}$$

$$a-x=\frac{a}{2\sin\phi+1}.$$

Substituting this value of $(a-x)$ in (3) we have

$$r=\frac{(a-x)\sin\phi}{1-\sin\phi}=\frac{2a\sin\phi}{(2\sin\phi+1)(1-\sin\phi)}=\frac{a\sin\phi}{\sin\phi+\cos 2\phi},$$

which is the required radius in terms of a and ϕ. We shall test the func-

tion (1) for a maximum or minimum, using the second derivative.

$$\frac{d^2y}{dx^2}=\tfrac{1}{2}\pi\left[\frac{2\sin\phi}{1-\sin\phi}(2a-6x)-4x\right].$$

Substituting the critical value (4) we obtain a negative result. Hence the function is a maximum. The particular value of r will now be found by substitution

$$r=\frac{a\sin\phi}{\sin\phi+\cos 2\phi}$$

$$a=16 \qquad \sin 30^\circ=\tfrac{1}{2}$$
$$\phi=30^\circ \qquad \cos 60^\circ=\tfrac{1}{2}$$

$$r=\frac{16\cdot\frac{1}{2}}{\frac{1}{2}+\frac{1}{2}}=8=\text{Answer.}$$

Solutions were also offered by Pascal Poe, Jr., Gunnison, Colo., Charles W. Trigg, Los Angeles, H. M. Zerbe, Wilkes-Barre, Pa., Julius Freilich Brooklyn, Hyman, Marcus, New York City, J. Slavin, Brooklyn, and W. R. Smith, Chicago.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1486, 1487. *G. Watson, John R. Whyte, and Colin LaZier, Upper Canada College, Toronto.*

PROBLEMS FOR SOLUTION

1502. *Proposed by Isadore Chertoff, Bayonne, N. J.*

If $a+b+c=0$, prove $\left(\frac{b-c}{a}+\frac{c-a}{b}+\frac{a-b}{c}\right)\left(\frac{a}{b-c}+\frac{b}{c-a}+\frac{c}{a-b}\right)=9.$

1503. *Proposed by Isadore Chertoff.*

The sides of a triangle are in arithmetic progression. If a and c are the smallest and greatest sides respectively, and if r and R are the radii of the inscribed and circumscribed circles, show that $6Rr=ac$.

1504. *Proposed by James A. Lemon, Eaton, Ohio.*

A ladder 12 ft. long is placed on a horizontal sidewalk so that it leans against a vertical wall. The distance from the foot of the ladder to the wall is adjusted so that it rests along the face of a cubical box, edge 4 ft. If one edge of the box is on the walk and the other edge against the wall, what is the shortest distance possible between the foot of the ladder and the wall?

1505. *Proposed by M. C. Bergen. A challenge to high school pupils.*

One hundred people attend a picnic. The men pay 5¢ for admission, the women pay 2¢, and the children get in at ten for a penny. The total receipts were $1.00. How many men, how many women, and how many children were at the picnic?

1506. *Proposed by Charles P. Louthan, Columbus.*

A ladder 80 feet in length stands with its base in the middle of the street and when leaned up against the buildings on either side it will reach to a certain height; but a 90-foot ladder with its base in the same place will reach on the buildings 20 feet higher. Find the width of the street.

1507. *Proposed by Charles P. Louthan.*

Find the equation of the line through the intersection points of the lines $x-2y-6=0$, $2x+3y+2=0$, and $5x+y+4=0$, $2x-7y-6=0$, without finding the intersection points of the lines.

SCIENCE QUESTIONS

May, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue. S. E. Cleveland, Ohio.)

This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings. Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific). Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers to make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

As a Mode of Recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 170 contributors have already been admitted to Membership. Classes or individuals, may become members by proposing a question or submitting an answer.

JOIN THE GQRA

NEW MEMBERS—GQRA—MAY, 1937

173. Joseph T. Hogan, Tulane University, New Orleans, La.
174. Helene L. Bourgeois, Franklin High School, Portland, Oregon.

QUIZ OF THE MONTH—QUIZ FOR MAY—C. W. TRIGG (GQRA, No. 20)

The title "Quiz of the Month" is following along the line suggested by Louis T. Masson (GQRA, No. 52) in the March, 1937, issue of SCHOOL SCIENCE AND MATHEMATICS. If we can get a good one, we will publish it every month under this or some better title that *our readers* may suggest.

Clay Herrick, Jr., (GQRA, No. 90) was QUIZ for April.

C. W. Trigg, (GQRA, No. 20) is QUIZ for May.

WHO WILL BE QUIZ FOR JUNE and for the MONTHS OF NEXT YEAR?

795. *Professor Charles W. Trigg, Cumnock College, Los Angeles, Cal. (GQRA, No. 20) sent in a copy of The Los Angeles Times, Sunday, January 10, 1937, which contained the following:*

"Problem No. 14.—A mine contractor had two lots of metal bars. Eight of the large size were as heavy as thirteen of the small size bars. Altogether there were forty-nine bars of metal, which he wished to have carried over a mountain pass.

The contractor made a bargain with two brothers who owned seven mules, to transport the metal over the pass. He paid them an even number of dollars, which they divided equally between them. They took no other money with them on the trip.

Some of the mules were weaker than others, and it was necessary to adjust the weight of the packs to the individual capacities of the mules. This was done, and no two mules carried the same weight of pack, although each carried seven bars, and no pack weighed as much as 300 pounds nor as little as 150 pounds.

After they were well started, one of the brothers found that he had left his pipe at the ranch. His brother had an extra one which was new, and sold it to him for just what he had paid for it, which was an integral number of dollars.

After this transaction the product of their respective money holdings (which were both prime numbers) was $9 less than it would have been before the sale of the pipe and exactly $70 more than the total weight of the seven packs of metal carried by the mules.

What was the weight of one bar of the larger size and what was the weight of the smaller bar?

(The writer of the article and the collector of the questions—L. J. Adams, Beverly Hills High School—says this is "the champion brain-twister" and that "We hereby challenge you to solve this one.")

YES, PEEBLES IS RIGHT

787. *A clipping from The Niagara Falls Gazette.*

What is the correct chemistry of this situation?

WARNS TRUCK THIEVES

Stolen vehicle has load of dangerous chemicals

Washington, D. C., Dec. 25 (AP)—This is a warning to the person who stole a truckload of chemicals from the driver's home here yesterday.

Meade Peebles, head of the Rosslyn (Va.) Chemical Company which consigned the chemicals to a plant in Baltimore, said today they were very dangerous.

Several steel cylinders on the truck contain chlorine gas, others ammonia.

If the two get together there'll be an awful explosion, Peebles said.

Answer by Joseph T. Hogan, Tulane University, New Orleans, La. (Elected to the GQRA, No. 173).

I am an enthusiastic reader of your Science Questions Section in *School Science and Mathematics*. Being an instructor in analytical chemistry I submit a possible solution to problem # 787, which will account for the warning that Peebles thought proper to make. Hoping that I may become a GQRA, I remain, Joseph T. Hogan.

The possible reasons for Peebles' warning:

When ammonia (vapor) and chlorine gases mix, the chlorine combines with the hydrogen of the ammonia and liberates nitrogen.

$$2\ NH_3+3\ Cl_2 \rightarrow N_2+6\ HCl.$$

Since there is an excess of ammonia gas there will be a reaction between the HCl formed in the above reaction with the formation of ammonium chloride.

$$HCl+NH_3 \rightarrow NH_4Cl.$$

When an excess of chlorine acts upon ammonium chloride in an aqueous medium (water vapor) drops of an oily liquid, mitrogen trichloride, are formed.

$$3\ Cl_2+NH_4Cl \rightarrow NCl_3+4\ HCl.$$

Nitrogen trichloride is extremely explosive, resolving itself into its constituents with the liberation of much heat.

DANGER FROM EXPLOSIVES CARRIED ON RAILROADS

It is a well-known fact that railroads carry large amounts of explosives. For that reason it is appropriate to quote from "Railroad Data" of March 26, 1937.

In the past ten years the railroads of the United States and Canada have transported billions of pounds of dynamite, black powder, and other dangerous explosives without a single explosion taking place and without any person being killed or injured. This remarkable record is disclosed in the 1936 annual report of the Bureau of Explosives, Association of American Railroads.

In 1936 the railroads of the United States and Canada transported approximately 400,000,000 pounds of dangerous explosives, which included, among other things, dynamite, high explosives of all kinds, black powder, blasting caps, and fulminate of mercury. In 1935 the amount transported was approximately 370,000,000 pounds.

The railroads in 1936 also transported great quantities of other dangerous articles, such as gasoline, acids, corrosive and inflammable liquids, and compressed gases without loss of life, except in the case of gasoline which caused four deaths. In 1935 nine persons were killed in connection with the transportation of these commodities.

Property loss in 1936 from accidents resulting in fires, leakages, and losses due to the transportation of dangerous articles other than explosives totaled $525,827, of which $252,000 resulted from accidents in connection with the transportation of gasoline.

SOME THINGS WALTER WINCHELL WANTS TO KNOW

796. *Some Things Walter Winchell Wants to Know. (From just one issue of The Cleveland News.)*

1. Why snakes never close their eyes?
2. Why crocodiles eat stones?
3. Why it is against the law in Kansas to eat centipedes in public?
4. What the dealers who buy secondhand chewing gum do with it?
5. Where the ice in Death Valley goes to when it melts—it doesn't leave any water?
6. Why for the past 12 years Hawaii's temperature has been steadily increasing?

MORE ABOUT EXPLOSIONS

797. *Hoffman's Ice-Cream Has Explosion and Fire* (March, 1937).

An explosion wrecked the Hoffman Ice Cream Store and was followed by a fire. Firemen reported that "there didn't seem to be much fire until we broke open a window." Then there was a burst of flame accompanied by a moderate explosion and the firemen had to put on their gas masks.

What could cause the explosion?

What might be the chemical reaction?

What refrigerant might make such a fire and explosion possible?

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762. *From a News Item. "Near Explosion in Court Room."*

In a court room in Cleveland (February 20, 1936) one Clausen on trial for robbery, held up a two-ounce vial of a "clear liquid" and said, "I am going to die here. If anyone tries to shoot me, you'll all go with me." Clausen usually escaped after one of his robberies by threatening to smash a vial of nitroglycerine at the feet of the persons he robbed.

Sergeant Ryan shot him in the hand holding the vial and he went down smashing the vial on the floor. Bystanders said there was a distinct "aroma of ammonia."

In the wake of the tumult the question arose: "What if Clausen had possessed a two-ounce vial of nitroglycerine and had smashed that high explosive? What would have happened?"

Answer to 762.

Cowles, Police Superintendent of Ballistics, said that if the vial had exploded in the courtroom probably the only victim would have been the man holding it; namely: Clausen. Cowles said that probably not a great deal of damage would have occurred even if the vial had contained nitroglycerine because the explosive would have spent itself within the confines of the high-ceilinged room. (Cleveland Plain Dealer, Feb. 21, 1936).

SCIENCE IN THE DAILY NEWS

798. *From the Cleveland Plain Dealer (U.P.) of March 23, 1937.*

Ray Woods of St. Louis jumped from the San Francisco-Oakland Bridge 189 feet above the water into San Francisco Bay. "As he dropped, his body folded into the jack-knife from which he intended to emerge before reaching the water. A strong wind struck the plunging body and it remained in the folded posture as it struck the water." Hospital authorities said his back was broken.

How fast was Mr. Woods traveling at the time he struck the water?

How long had it taken him to fall? (189 feet).

What was his impact? (Assuming a weight of 175 lb.)

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799. *From an account of the New London, Texas, gas explosion.*

Dr. E. P. Schoch, Professor of Chemistry in the University of Texas is quoted as saying that "the maximum explosive mixture of natural gas with air is 6.5%."

What is the perdominating constituent of the gas which caused the explosion?

(Equation and solution, please.)

SNAPDRAGON

800. *Why is the snapdragon flower so-named?*

DISTINCTION TEST IN BOTANY

801. *Submitted by Sister Mary Stanislaus Costello, RSM, (GQRA, No. 152), Mercy High School, Milwaukee, Wisconsin.*

SECOND SEMESTER EXAM. JUNE, 1936.

Distinguish between the following:

1. Botany	Zoology
2. regular	irregular flowers
3. fertilization	pollination
4. flower	fruit
5. apetalous	asepalous flowers
6. peduncle	pedicels
7. corolla	petal
8. poppy	any flower studied
9. calyx	corolla
10. plant	animal (3)
11. core of apple	core of pineapple
12. monoecious	dioecious plants
13. epicotyl	hypocotyl
14. staminate	pistillate flowers
15. calla lily	Easter lily
16. exocarp carp	endocarp mesocarp
17. pea	corn seedlings
18. anther	ovary
19. leaves	cotyledons
20. bark	epidermis
21. perianth	inflorescence
22. perianth	floral envelope
23. root	stem
24. pollen	ovule
25. leaf of corn seedling	leaf of bean seedling
26. epicotyl	plumule
27. seed leaves	leaves
28. strawberry	fig
29. seedling	plant
30. dicotyledonous	monocotyledonous plants
31. pea	bean seedlings
32. types of pollination (4)	
33. Pome	Pepo families
34. hilum	micropyle
35. sepal	calyx
36. tulip	lily (2)
37. sweet pea	snapdragon
38. stamen	pistil
39. perfect	imperfect flowers
40. xylem	phloem
41. rose	carnation
42. angiosperm	gymnosperm
43. stamens of snapdragon	stamens of sweet pea
44. raceme	spike flowers
45. simple	compound flowers
46. spermatophytes	thallophytes

47. Berry	Drupe Families
48. complete	incomplete flowers
49. stigma of lily	stigma of snapdragon
50. tomato	any member of the same family

TO ALL 174 MEMBERS OF THE GQRA—

REMEMBER

The Cleveland Exposition—GREAT LAKES EXPOSITION—will again be open this summer. Visit Cleveland.

Meet me at Cleveland on Saturday, July 31, and we'll all go down to Pen 'Bryn at Geneva, Ohio and have a SCIENTIFIC PICNIC,

Yours for July 31st, August 1st.

Ed Jones.

BOOK REVIEWS

An Invitation to Mathematics, by Arnold Dresden, Swarthmore College. Cloth. Pages xii+453. 13.5×20 cm. 1936. Henry Holt and Company, One Park Avenue, New York. Price $2.80.

We have seen recently several books written for the purpose of making mathematics interesting and at the same time to serve the serious purpose of satisfying a large class of people who desire to know something about its nature and its place in science and philosophy. This book by Professor Dresden is an addition to the list.

It is an attempt to take the individual who has a fairly good training in high school mathematics and guide him into some of the more advanced fields without requiring him to become proficient in manipulation. To do this the author has selected some significant topics which can be presented without an extensive preparation.

Among the topics discussed are in order: Pythagorean triples, infinite sets, the number field, scalars and vectors including complex numbers, exponent and logarithms, factorization, number scales, foundation of geometry, Non Euclidian geometry, functionality, and elements of the calculus, and projective geometry.

We find numerous exercises following each topic with such picturesque headings, as "Rest after the Climb," "Learning to Swin," "To secure the Treasures," and "Playing on the Walls." The exposition is set forth in an unusual and interesting style. The book should be read by every teacher of secondary and junior college mathematics.

J. M. KINNEY

Analytic Geometry, Alternate Edition, by W. A. Wilson, Ph.D., Professor of Mathematics, Yale University and J. I. Tracey, Ph.D., Associate Professor of Mathematics, Yale University. Cloth. Pages xvii+296+18. 13.5×20 cm. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. 1937. Price $2.12.

This edition does not differ radically from the edition of 1925. Numerical data in problems have been changed and new problems have been added. In the chapter on curve fitting the method of moments has been introduced, spherical and cylindrical coordinates and space curves have been added to the chapter on solid geometry.

J. M. KINNEY

Plane and Spherical Trigonometry, by Joseph B. Rosenbach, Professor of Mathematics; Edwin A. Whitman, Associate Professor of Mathematics; and David Moskovitz, Assistant Professor of Mathematics, The Carnegie Institute of Technology. Cloth. Pages x+336+xxvii. 13.5×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

Plane Trigonometry, by Joseph B. Rosenbach, Professor of Mathematics; Edwin A. Whitman, Associate Professor of Mathematics; and David Moskovitz, Assistant Professor of Mathematics. The Carnegie Institute of Technology. Cloth. Pages x+288+xxiii. 13.5×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.80.

These two books are essentially the same with the exception that one contains additional chapters on spherical trigonometry. The material is flexible in that each topic is a complete unit in itself, thus, enabling the teacher to provide for various groups of students and courses. The first three chapters contain a discussion of trigonometric functions which are defined for all angles and then for acute and quadrantal angles, the use of trigonometric tables and the solution of right and oblique triangles without use of logarithms. Chapter four covers radian measure and its application. The topics of identities and equations are treated in chapter five. Chapters six and seven are devoted to logarithms and an analysis and solution of triangles by use of them. Graphical representation and solution of equations, inverse functions and complex numbers are treated in the last three chapters. The treatment of spherical trigonometry is approached in much the same manner with astronomical and terrestial applications.

The books contain many illustrations, illustrative examples and an abundance of problems of which the answers to all odd numbered ones are included. The historical notes and suggestions should be found interesting as well as valuable to study. The attractive binding in water-proof covers further indicates the modern trend of these texts.

L. C. WARNER

Radio Field Service Data, by Alfred A. Ghirardi. Second Revised Edition. Cloth. Pages x+436. Loose Leaf. 14×20.5 cm. 1936. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $2.50.

This is a book of quick reference for the installation and servicing of radio receivers. It is made in loose-leaf form so that it can be conveniently kept up to date with the latest data on tubes and receiver changes by the insertion of new supplements issued twice yearly. A complete tabulation of intermediate peak frequencies for all receivers, old and new, are listed alphabetically according to manufacture. Case histories, symptoms and remedial suggestions are given for all-wave and auto radios as well as for the regular broadcast receivers. Wiring diagrams and ignition information are compiled for most cars. Useful data regarding the characteristics of both glass and metal tubes, RMA color codes, magnet wire tables, metric prefixes, wavelength-frequency-L×C tables, grid bias resistors, power ratings and transformer design are given. Service men and those interested in radio servicing should find this book a valuable source of up-to-date information.

L. C. WARNER

More for Your Money, A Buyer's Guide, by H. Bennett. Cloth. Pages xii +251. 15×22.5 cm. 1937. Chemical Publishing Company, Inc., 148 Lafayette Street, New York, N. Y. Price $2.75.

This is an interesting and entertaining book which reveals many of the misunderstandings of the buyer of everyday household needs. The author points out that few laws are ever violated in advertising propaganda, however, investigation shows that the wild claims set forth in the advertising programs of manufacturers of such products in light of the scientific facts cannot be confirmed. Likely questions are answered regarding the purchase of various products. Each product mentioned is discussed as to requirements of good quality and cost. The 251 pages divided into thirty-nine chapters cover the author's method of judging cosmetics and drugs, foodstuffs, liquors, soaps, cleaners, crockery, glassware, refrigerators, radios, furniture, fabrics, clothing, leather goods, rubber products, jewelry, building materials, automobiles, oils, insurance, etc. Frequent comparative notations are made as well as the means of revealing poor and undesirable merchandise. Advice for purchasing and home testing are given. The procedures for testing undesirable or harmful constituents have been made simple enough so that anyone can make them and so they utilize a minimum number of chemical reagents. The chapters on cosmetics, drugs, and foodstuffs should be found especially interesting to those who like to perform such tests. This authoritative buying guide should find favor as a reference book for every day purchasing.

L. C. WARNER

The Living World, by Samuel H. Williams, Professor of Zoology in the University of Pittsburgh. Cloth. Size 5.5 × 8.5 in. Pages 704. Illustrations: 240 figures in the text and 39 plates. Published by the Macmillan Company, New York. 1937. Price $3.60.

This an unusual textbook, a pioneer in its field. The author calls it a "textbook of natural science, designed to fulfill the requirements of a cultural course in biology and to serve as a basic text in Nature Study, Field Biology, and Elementary Ecology Courses." We think it will be very helpful as a reference book for students in biology courses in secondary school, though its use has been in college and field laboratories.

The book has some unique features which enhance its usefulness. The illustrations are very abundant, the 39 plates each containing from 4 to 20 or more figures which will be helpful for identification purposes. The references to literature bearing on the topics of the various chapters are very complete. Particularly useful will be the tables of classification with abundant examples for each division. There are also some keys for use in identification.

The general character of the book may be indicated by some of the chapter headings. "The Colors of Animals; The Defenses and Life Span of Animals; Sound, its Production, Perception, and Function in the Biological World; The Classification of Animal Habitats; The Life in Caves; The Life on Ocean Beach." There is a chapter of Practical Suggestions for Study—especially the collection and care of the collected material. Appendix A consists of 200 "interesting facts about Nature" with answers.

We pronounce this book, not only interesting but valuable and predict it will find a very useful field for its use.

W. WHITNEY

The Insect Man, by Eleanor Doorly. Introduction by Walter De La Mare. Illustrated by Robert Gibbings. Cloth. Size 5.5 × 8 in. Pages 180. Woodcut illustrations. Published by D. Appleton-Century Company, New York. 1937. Price $1.50.

The "insect man" is Jean Henri Fabre. The book is based on tales from Fabre, and on a journey by the author to the scenes of Fabre's life. It is

intended for boys and girls who like tales from real life—not fables. Probably the tales will be interesting to older people as well as to lively-minded children.

It is expected that the book will be used for readings or as a source book for stories of insects which Fabre has immortalized by his studies and accounts of their lives. It is a worth-while book for the purpose as Miss Doorly conceives its use.

W. WHITNEY

Youth Studies Alcohol. A study of the Effects of Alcohol for the Seventh, Eighth, and Ninth Grades, by Kenneth M. Harkness, M. A., and Lyman M. Fort, M.A., L.L.D. Original drawings by Kurt Welanetz. Cloth. Size 5.5 × 7.75 in. 124 pages. Many figures drawn exclusively for the text. Published by Benj. H. Sanborn & Co., Chicago, New York, and Boston, 1936. Price 64 cents.

"Youth Studies Alcohol" has been written for use in junior high schools. The authors have aimed, in this book, to make the material scientific and also to make it interesting. The information presented, is well set forth, and factual, and designed to catch and hold the attention of the student. The book may be used as a reader followed by class discussion. It is not designed to be a textbook in the usual manner such books are used. It covers the important topics of the uses of alcohol and its effects, in a thorough going manner.

W. WHITNEY

School Health Problems, by Lawrence B. Chenoweth, A.B., M.D., Professor of Hygiene, University of Cincinnati, and Theodore K. Selkirk, A.B., M.D., Instructor in Pediatrics, College of Medicine, University of Cincinnati, with a chapter on School Health Administration by Richard Arthur Bolt, M.D., Dr. P. H. H. Director, Cleveland Child Health Association; Associate in Hygiene, Western Reserve University. Cloth, Size 5.5 × 8.75 in., 386 pages, 112 figures in the text and XV Tables. Published by F. S. Crofts & Co., New York. 1937. Price $3.00.

This book was written for students of Education, and teachers in service. It is especially designed to acquaint those interested, with the health problems in School. It is not "greatly concerned with the technique of performing health examinations." That is left to the school physician or trained nurse. Their important goal is the showing of what problems exist in the field of school health.

Everything in this field which the authors have chosen is treated carefully and thoroughly. As an example of this thoroughness we may cite the very numerous references for "further study" at the close of each chapter, in some cases several pages of such references. The illustrations are very practical and helpful.

We cannot take the space to say much about the content of the book, but suffice it to say that the field of school health problems is very fully covered. However, we will list a few of the more suggestive and important chapter headings. "Factors which influence Growth, Nutrition, Malnutrition, Communicable Diseases, Seeing and Light, Acoustics and Hearing, Handicapped Children, Tuberculosis, Mental Hygiene, Physical Education, Accidents." It would seem to the reviewer that no student of the problems of school health can afford to overlook the help this book gives.

W. WHITNEY

The High School Science Teacher and His Work, by Carleton E. Preston, Associate Professor of The Teaching Of Science, University of North

Carolina. Cloth. Pages xvii+272. 1936. McGraw-Hill Book Company, New York. Price $2.00.

This interesting book is written primarily for the beginning teacher of science. It is the type of book the inexperienced teacher needs most of all. The book presents the problems in the teaching of science in a very practical way. Its style is simple and direct. Its philosophy is sound. Its suggested methods of teaching are workable in the classrooom and are based on the broad experiences of a successful teacher.

The first chapter—"What It Means To Be A Science Teacher," is the best presentation of the problems of the beginning teacher I have seen. This statement gives the general philosophy of the author—"It is the task of the science teacher to develop a finer and better adjusted type of young manhood and womanhood through the medium of science, not to extend science through the medium of young people." Some other chapters which are distinctly helpful to the beginning teacher are—"Present Day Objectives"; "Choice Of Subject Matter"; "Steps In Reasoning"; "Teaching How To Study"; "Safeguarded Thinking"; "Individual Laboratory Work"; and "Tests And Testing."

Each chapter contains a list of exercises for report and discussion which are based on a carefully selected list of references. These exercises furnish valuable helps to the beginning teacher in interpreting his reading in terms of present day problems.

This book is intended for use in science methods courses in Universities, colleges and normal schools. It will be an inspiration to all science teachers.

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Elements of Mechanics, by Henry A. Erikson, Professor of Physics, University of Minnesota. Third Edition. Cloth. Pages xx+269. 13.5×20.5 cm. 1936. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.25.

This book forms the basis for the work of the first quarter in general physics at the University of Minnesota, and presupposes a knowledge of college algebra and trigonometry. The third edition does not differ greatly from the previous edition but a number of minor improvements have been made which assist both teacher and student.

One valuable addition is the insertion just after the Introduction of a complete table of the symbols used in the book. A few of the drawings have been revised, improvements have been made in some of the illustrative solutions, and certain points in the textual material have been clarified. The lists of supplementary problems have been enlarged and improved.

Instructors who use this text will find all the fundamental principles clearly discussed and illustrated by drawings and completely solved problems. An abundance of material for assignment is provided, but the practical applications of the principles and all historical and human interest phases are left for the instructor.

G. W. W.

Principles of Electric and Magnetic Measurements, Part I—Electricity, by P. Vigoureaux of the National Physical Laboratory, Teddington; Part II—Magnetism, by C. E. Webb of the National Physical Laboratory, Teddington. Cloth. Pages xi+392. 14.5×22 cm. 1936. Blackie and Son, Limited, 50 Old Bailey, London, E.C. 4. Price 20s. net.

This is a textbook of experimental electricity and magnetism of college grade. It is not to be confused with the ordinary type of laboratory manual since it does not give specific directions for performing experiments. It discusses the theory of all the instruments ordinarily found in use in classes in electrical measurements, gives the sensitivity and precautions necessary for obtaining results and protection the instrument. Part I on electricity includes chapters on the action between electric charges, magnets and currents in magnetic fields, heating action of currents, the potentiometer, networks of conductors, electrolysis, electro-magnetic induction, the thermionic tube, measurements at radio frequencies, and electric charges in electric and magnetic fields. The last three chapters include many of the instruments designed for use in the development of radio, in the study of the discharge of electricity through rare gases, in x-rays measurements, and in the field of radioactivity. Part II on magnetisms contains one chapter on the classical instruments used in magnetic measurements and one chapter on those more recently designed requiring intense magnetic fields. This includes measurement of susceptibility of para- and diamagnetic materials, magnetostriction, effect of temperature on magnetic properties, magneto-electric and magneto-optic effects, the Barkhausen effect and discontinuities in magnetization.

The inclusive and thorough nature of this text makes it a very useful tool for all students in electrical measurement courses.

G. W. W.

Frontiers of Science, by Professor Carl T. Chase, Assistant Professor of Physics, New York University. Cloth. Pages xi+352. 13.5×21.5 cm. 1936. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.75.

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along an extensive front. It is not to be expected that one writer will be able to make a critical analysis of the work of all sectors that will have uniform reliability; but Dr. Chase has done a very creditable piece of work. He points out that in the study of astronomy investigations center about the possibilities of life on other planets, the study of variable stars and of nebulae, search for a satisfactory theory of the evolution of the stars, applications of the theory of relativity and of statistical methods to supplement the experimental evidence collected by telescope and spectroscope of the extent and motions of other "universes." Physics strives by use of instruments of almost incredible accuracy and sensitivity and by the application of the quantum theory and quantum mechanics to discover and measure the ultimate particles of matter and energy and to determine the nature and source of cosmic rays. Chemistry uses the tools supplied by research in physics to synthesize compounds rivaling those supplied by nature, to improve old industries and establish new ones, to investigate the action of catylists, and to determine the ultimate nature of the bonds that join elements into compounds. In the field of biological science investigation centers around the study of prevention of disease, hormones, vitamins, the endocrine glands, the study of inheritance, and the riddle of life.

It is on these frontiers that the sciences merge. The physicist becomes an astronomer, the chemist a physicist, and the physical scientists join with the biologists to make new advances in the sectors of biophysics and biochemistry.

G. W. W.

Materials of Industry, by Samuel Foster, Mersereau, Chairman, Department of Industrial Processes, Brooklyn Technical High School. Revised Edition. Cloth. Pages xviii+541. 13.5×21.5 cm. 1936. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

This is a revised edition of a book originally prepared for use as a textbook in Brooklyn Technical High School. Its purpose is to give to high school students some knowledge of the principal materials used in industrial processes, their sources, methods of locating them, processing, conservation of supply, and specific uses. The main topics are lumber, nonmetallic minerals (petroleum, coal, building stone, concrete, glass, etc.), iron and steel, the nonferrous minerals (copper, aluminum, lead, tin, alloys, etc.), and miscellaneous products such as rubber, bakelite, paint, varnish, and stains.

The book is well organized for instructional purposes. Following each discussion of textural matter are a glossary of technical terms, a list of questions for study and investigation, and a summary. It is a valuable book for supplementary reading by science and shop pupils in schools where a separate course in materials is not given.

G. W. W.

Properties of Matter, by F. C. Champion, Lecturer in Physics, University of London (King's College) and N. Davy Semior Lecturer in Physics. University College, Nottingham. Cloth. Pages xiv+296. 14.5×22 cm. 1936. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 15s. net.

This excellent text on selected topics dealing with the properties of matter presupposes familiarity with the fundamentals of mechanics and ability to use the calculus. It is well arranged, uses clear, concise language through-

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out, and makes constant use of the mathematical method of presentation. A short set of problems arranged by chapters, with answers and hints for solution is given in the final pages. Each topic treated is discussed in a very thorough manner; e.g., the chapter on capillarity covers sixty pages. The chapter headings will give our readers some idea of the contents. They are as follows: Units and Dimensions, The Acceleration Due to Gravity, The Newtonian Constant of Gravitation, Elasticity, Compressibility of Solids and Liquids, Seismic Waves, Capillarity, Surface Films, Kinetic Theory of Matter, Osmotic Pressure, Diffusion, Viscosity, Errors of Measurement; Methods of Determining Planck's Constant.

G. W. W.

PROGRAM OF SPRING RALLY

10:00 A.M. Reunion at Hudson, Ohio, March 13, 1937.

10:20 A.M. Address of Welcome—Dr. Joel B. Hayden, Head Master, Western Reserve Academy.

10:30 A.M. Chemists and the Rubber Industry (Demonstration and Lecture)—Mr. L. M. Freeman, Manager of Raw Materials Inspection and Development Department, Goodrich Tire and Rubber Company, Akron, Ohio.

11:00 A.M. What Social Scientists can use from the Field of Mathematics and Natural Sciences.—Dr. C. E. Gehlke, Professor of Sociology, Western Reserve University.

11:30 A.M. The Future of Science in Education.—James C. Adell, Chief of Educational Research, Cleveland Public Schools.

11:55 A.M. The Future of Mathematics in Secondary Education.—W. O. Smith, Head of the Mathematics Department, South High School, Cleveland, Ohio.

12:15 P.M. Music—Western Reserve Academy Glee Club—Song Artists, Business Meeting—Election of Officers.

12:30 P.M. Luncheon Western Reserve Academy Dining Auditorium Luncheon Lecture: Hawaiian Experiences—Lecture and Pictures.—Dr. J. Paul Visscher, Western Reserve University.

2:30 P.M. Visit to Sugar Bush of R. B. Simon—Producer of Champion "Amber Sweets," Follow Nature's Trail under the Leadership of Dr. J. Paul Visscher, Western Reserve University.

NATURE GUIDE SCHOOL

In answer to a need created by the recent growth of community parks and playgrounds and the rapid development of organized camping programs, Massachusetts State College will open a *nature guide school* here this summer.

The purpose of the school will be to train leaders in various aspects of nature activity and to offer a further understanding and appreciation of outdoor surroundings. An effort will be made to equip young men and women for such positions as ranger naturalists for National Parks, nature councillors in summer camps, scout naturalists, and 4-H club leaders, as well as to give them a generally broad view of this aspect of life.

A six-week course will be presented from July 6 to August 14 this year, with variations to be offered in the course in successive summers over a four-year period. A Nature Guide's Certificate will be awarded at the end of the four years' training.

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Dr. William Gould Vinal, who was recently named to the faculty of the state college as professor of natrue education, will be director of the school. Dr. Vinal, a native of Norwell, Mass., is a graduate of the Massachusetts State Teachers' College at Bridgewater, and received the degree of M.A. from Harvard and Ph.D. from Brown University. He has taught nature education at a number of educational institutions and has held numerous park and camp positions. For ten years he taught nature recreation for the National Recreation Association. He is the author of "Nature Guiding" and is president of the American Nature Study Society.

The students will spend most of their time in the out-of-doors, living in tents situated nearby the school in white pine woods. Located on the northern boundary of the state college's Mt. Toby forest, the school has easy access not only to the beautiful features of this managed forest, but to the expanse of the Connecticut Valley. On the 755 acres of forest owned by the college, there are a wide range of forest types and biological features present, all readily accessible. Forestry and wild life experimental work are being carried forward regularly in the forest and will be available for instruction purposes to students in the Nature Guide School.

In the first year of the course studies will be made of birds, of ponds and streams, and in nature guidance and in practical and field nature experience. In succeeding summers studies will include insects, vertebrates, physiography, flowering plants, gardening, scouting, trees and shrubs, non-flowering plants, and handcraft, as well as further practical nature experience.

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

By Edwin W. Schreiber, *Secretary*

The 18th Annual Meeting of the National Council of Teachers of Mathematics was held in Chicago, February 19–20, 1937. This was the largest meeting in the history of the Organization, 836 registered and the total attendance was well in excess of 1,000. The opening meeting began at 8 P.M. in the Grand Ball Room of the Palmer House with President Martha Hildebrandt in the Chair. The Address of Welcome was made by James E. McDade, Asst. Superintendent of Schools, Chicago, and the Response by Mrs. Florence Brooks Miller, 1st Vice-President, Shaker Heights, Ohio. Professor Albert A. Bennett, Brown University spoke on "Mathematics and Life." Beulah I. Shoesmith of Hyde Park High School, Chicago presented through some 20 high school students a series of projects on high school mathematics which was much appreciated. The results of the Annual election were as follow: For Second Vice President, J. T. Johnson, Chicago Normal College; for three members of the Board of Directors, William Betz of Rochester, N. Y., H. C. Christofferson, Oxford, Ohio, and Edith Woolsey, Minneapolis, Minnesota.

Three simultaneous meetings were held at 9:30 A.M. Saturday morning. (1) Arithmetic Section (2) High School Section (3) Junior College Section. For the Arithmetic Section there were 3 papers, "Significance, Meaning and Insight, These Three" by B. R. Buckingham, "Teaching Pupils to Teach Themselves" by H. G. Wheat, and "Methods and Devices for the Development of Resourcefulness" by Arthur S. Otis. There were four papers in the High School Section. "Providing for Individual Needs in Mathematics" by Virgil S. Mallory, "An Experiment Dealing with Slow Learning Pupils in Mathematics" by Raleigh Schorling, "Curriculum Hints from the Night School" by C. O. Donnelly, and "Revealing the

SHADOWS OF NUMBERS

Upon the level land a fantastic shadow flits. It comes from nowhere; small at first, then larger, shapeless, then formed like humpbacked Punch. It springs forward, hesitates, shrinks, expands, now formed like a bull, but charging backwards, again it shrinks and vanishes.

In the sunlight, above the land, a square of paper floats. First, floating flat and edgewise to the sun it casts no shadow. The wind seizes it, crumples it, drives it forward, tosses it far upward, recrumples it, lets it fall, eddys it backward and again unfolds it into a square, edgewise to the sun.

* * *

In mathematics there is a level space which is the habitat of the roots of algebraic equations. An algebraic equation of the *n*th degree has *n* roots, all complex numbers. All complex numbers dwell in one plane.

The plane of complex numbers is a self sufficient and self contained flatness. Shadows also dwell in such a self sufficient and self contained flatness.

He who gazes at shadows only can believe that the universe of shadows is all; beyond the shadows there is nothing; there is need of nothing; indeed, there can be nothing, for the universe of shadows is self contained. A self contained universe is an ultimate idea.

So the complex roots of an algebraic equation occupy a plane universe which seems to form an ultimate mathematical idea because it is self sufficient and self contained.

Every algebraic equation craves a solution. This craving is satisfied, or is apparently satisfied, by a superficial solution in complex numbers. This complex solution furnishes that illusion of thin, but perfect, self sufficiency which satisfies, thoroughly satisfies, a watcher of shadows.

Shadows crawl in the plane of half truth while reality flies above through the space of whole truth. Reality flies with precision but shadows crawl in ambiguity. When lying shadow halts, who can tell whether flying reality halts or merely ascends or descends with undiminished speed?

* * *

Does a shadow desire to leave its habitat? Can a shadow spring upward out of flatness into space?

Consider a picture. Viewed with the naked eye this picture is flat, but the picture is a stereograph, which, viewed through a stereoscope does spring upward out of flatness.

There is a stereoscope for the eye of the body; there is also a stereoscope for the eye of the mind.

The roots of an algebraic equation are mathematical stereographs. Viewed directly the roots lie in the flat universe of the complex numbers; viewed through a mathematical stereoscope the roots unfold into the boundless universe of the multifoliate numbers.

The superficial solution of an algebraic equation in complex numbers is but the shadow of a solid solution in multifoliate numbers.

The complex roots of an algebraic equation are like the petals of a rose, pressed flat, the multifoliate roots of the equation are like the petals of a rose, full blown.

* * *

For those who desire, for the eye of the mind, stereographic views of the roots of algebraic equations, we offer three monographs by Robert A. Philip.

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Vitality of Mathematics" by Kate Bell. Three papers were presented at the Junior College Section, "Off the Beaten Path" by Mayme I. Logsdon, "Some Problems of Junior College Mathematics" by H. W. Bailey, and "Business and Finance Mathematics in the Junior College Curriculum" by W. S. Schlauch. The Discussion Luncheon held at noon on Saturday was a distinct success, 409 attending this function. At the General Meeting held at 2:30 P.M. Mr. William Betz presented a moving picture entitled "Classroom Project in Intuitive Geometry." Professor W. D. Reeve addressed the audience on "Mathematics and the Integrated Program." Three moving pictures presented through the courtesy of the University of Chicago were much appreciated by the audience.

The Annual Banquet in the Grand Ball Room of the Palmer House was indeed a fitting close to the two-day session and was attended by 275. Special recognition was given to the Honorary President Dr. Herbert E. Slaught in honor of his 75th birthday. A novel part of the occasion was a speech by Professor Slaught broadcast to the group from a record previously prepared. President Hildebrandt moved the adoption of a set of resolutions honoring Professor H. E. Slaught which were unanimously adopted by a rising vote. Professor Charles A. Hutchinson read with keen insight the address which had been prepared by Professor H. E. Buchanan of Tulane University, New Orleans, on "A New Deal from Old Cards." Due to illness Professor Buchanan was unable to appear. The Mathematical Exhibit occupying the entire available space in the foyer leading to the Grand Ball Room was a very attractive feature of the Annual Convention. Miss Laura E. Christman, Senn High School, Chicago was General Chairman of this function.

BONE CHANGES IN RICKETS HAVE HEREDITARY BASIS

Heredity plays a part in causing the bone changes seen in rickets, it appears from studies reported by Dr. George L. Streeter, of the Carnegie Institution of Washington, at the meeting of the American Association of Anatomists.

Rickets itself, of course, is not inherited. It is caused by faulty diet, lack of vitamin D being the specific cause. When a child gets rickets his bones do not develop properly. Extreme degree of this faulty bone development is seen in the bow-legs and bulging foreheads of some rachitic children.

The tendency to abnormal bone development in rickets is inherited, Dr. Streeter found in the course of his studies, which were made with the cooperation of Dr. E. A. Park and Deborah Jackson of the Johns Hopkins University. The studies were made with two strains of rats, one of which was much more vulnerable to rickets than the other. The vulnerable strain reacted more severely to a rickets-causing diet than the non-vulnerable strain.

MINE FATALITIES CUT

The record of mine fatalities in the last three years, in the United States, is the best in the history of the mining industry, reports the U. S. Bureau of Mines. Due to increasing study of the causes of mine explosions the number of yearly deaths has been cut to an average of 40 a year from the average of 542 deaths yearly prior to the founding of the Bureau of Mines in 1910.